



New Jobs Across North Carolina

A STRATEGIC PLAN FOR GROWING THE ECONOMY
STATEWIDE THROUGH BIOTECHNOLOGY

JANUARY 2004

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Message from the Governor

Economic development in North Carolina has always been guided by three core beliefs: progress, education, and innovation. Our state's biotechnology industry has been built on these beliefs. Today it is an essential economic engine that can benefit all North Carolinians.

North Carolina's biotechnology industry ranks among the nation's five largest, with more than 150 companies employing 18,500 people and generating annual revenues of \$3 billion. Despite the economic downturn, this industry is growing 10 to 15 percent a year. Our universities are discovering and developing new technologies, new companies are being created, established companies are expanding, and companies are moving new products toward the market.

Although we have had much success, I believe that we have only scratched the surface of North Carolina's potential in biotechnology. To reach that potential, we need a clear roadmap to the state's biotechnology future — a plan that fully taps North Carolina's many resources to create jobs and products for today and the future.

With this imperative in mind, last summer I asked former governors Jim Hunt and Jim Martin to chair a blue ribbon steering committee charged with developing a strategic plan for maintaining and improving North Carolina's strong position in biotechnology. For the past six months, with able support from the North Carolina Biotechnology Center, the best and brightest scientists, educators, business and government leaders, university and community college leaders, economic developers, and biotechnology experts from every corner of North Carolina have been working hard to develop this plan.

This report, *New Jobs Across North Carolina: A Strategic Plan for Growing the Economy Statewide through Biotechnology*, is the culmination of that effort. It includes recommendations on how we can attract and grow new companies; train and improve our workforce; strengthen partnerships among businesses, universities and community colleges, and government; and improve math and science K-12 education.

New Jobs Across North Carolina should be carefully considered. I know that my administration and especially the Department of Commerce will take advantage of this report as we develop next steps in economic development strategy and determine how best to position North Carolina to gain the economic and social benefits from biotechnology.

North Carolina should be on every company's short list of places to carry out biotechnology research, development, testing, and manufacturing. Working together, I believe that we can and will achieve that goal.

— *Michael F. Easley*
Governor, State of North Carolina

A Strategic Plan for Growing the Economy Statewide through Biotechnology

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Message from Gov. James B. Hunt and Gov. James G. Martin *Co-Chairs, Strategic Plan Steering Committee*

When the North Carolina Biotechnology Center was created in 1981, it was the first state-supported biotechnology initiative in the world. No other state or country has established such a comprehensive and effective model to stimulate biotechnology development. As a result, North Carolina has emerged as a leading place for biotechnology growth and development, creating jobs and improving our quality of life.

Now, more than 20 years later and with biotechnology growing at a more rapid pace than ever, we have put together a strategic plan to guide us through the next 20 years, with the ultimate goal of having 125,000 biotechnology-related jobs by 2023. To achieve this goal, we must get down to business fast by implementing the strategies in this plan. Strong cooperation among government, business, and academia is required to sustain the momentum that has put North Carolina among the nation's top five biotechnology states. We must continue to recruit new companies, expand existing companies, and encourage spinouts from companies and universities, and we must accelerate the pace at which we do so. We are fortunate in North Carolina to have the ability to implement all of these efforts in all parts of the state. Biotechnology applications in North Carolina's main industries — agriculture, health care, environmental sciences, forestry, and many others — are already spreading biotechnology beyond Research Triangle Park and into other areas of the state.

North Carolina has all of the essential ingredients for success, including top-ranked universities and community colleges, a capable work force, and a high quality of life. We will continue to rely on these strengths to attract biotechnology companies to our state, but we must enhance them even further and be creative and innovative in meeting the competitive challenge. We already have a great foundation on which to build.

We are at a competitive crossroads with many other states looking to recruit biotechnology companies. In this critical time, we must find the resources needed to implement this strategic plan effectively and efficiently to make sure that North Carolina is the most attractive state for companies looking to locate or expand. We have the potential to create thousands of new jobs in every part of North Carolina by applying these strategies.

Ever since the Wright Brothers made their historic flight at Kitty Hawk in 1903, North Carolina has been a leader in technology. One hundred years later, North Carolina is still cultivating that visionary spirit. As we celebrate being "First in Flight," let us also strive to be first in biotechnology.

— *The Honorable James B. Hunt, Jr.*
*Womble Carlyle Sandridge
& Rice, PLLC*

— *The Honorable James G. Martin*
Corporate Vice President
Carolinas HealthCare System

Message from the President of the Biotechnology Center

Six months ago, Governor Easley charged the Biotechnology Center with developing a long-term strategic plan to guide future state investments in biotechnology and appointed a blue-ribbon steering committee to help facilitate our success. To ensure broad participation and diversity of views in the planning process, we promptly convened nearly 120 North Carolinians representing our many industrial, academic, governmental and community partners throughout the state. The result is *New Jobs Across North Carolina: A Strategic Plan for Growing the Economy Statewide through Biotechnology*.

The plan's stated goal of 48,000 and 125,000 biotechnology-related jobs in North Carolina by 2013 and 2023 respectively is clearly ambitious. To those of us familiar with North Carolina's strong biotechnology assets, the goal is aggressive but fully achievable. Success, however, will depend on substantial and sustained investments in the strategies outlined in this plan and strong support from the parties involved with their implementation.

Accounting for 10 percent of all U.S. biotechnology jobs and revenue and with the fastest rate of growth of new companies in the country, North Carolina is already a leading site for biotechnology economic development. *New Jobs Across North Carolina* builds upon that success by leveraging the talents and resources of all participants in our large and cohesive biotechnology community. The plan lays out an ambitious but realistic roadmap for moving the entire state forward in biotechnology development. The plan stresses new job creation but does so without neglecting important ethical, social and cultural considerations.

New Jobs Across North Carolina presents a comprehensive approach to new job creation that balances support for university and company spinouts with the attraction of more mature and emerging life sciences companies to North Carolina. The 54 strategies described in the plan take advantage of existing strengths and infrastructure and continue to build on recent investments in workforce training and regional initiatives. Biomanufacturing is given priority attention for its unique ability to bring biotechnology-related jobs to the more rural parts of North Carolina. Creating and attracting biotechnology start-ups and strengthening biotechnology development throughout the state are also identified as immediate priorities.

The Biotechnology Center looks forward to working with the Governor, Council of State, General Assembly and all of North Carolina's biotechnology community to implement the strategic plan. Our thanks go to Steering Committee Co-chairs Jim Hunt and Jim Martin and all participants for their valuable input to the strategic plan. On a personal note, I would like to thank the Board of Directors of the Biotechnology Center for their support throughout the planning process and their unanimous endorsement of the final product. Most importantly, I thank my staff at the Biotechnology Center and acknowledge their enormous contributions to the strategic plan.

— Leslie M. Alexandre, Dr.P.H

President and Chief Executive Officer, North Carolina Biotechnology Center

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Executive Summary

North Carolina's economy is in transition. As manufacturing jobs in traditional industries decline, new opportunities for job creation must be identified and aggressively pursued. Few sectors offer as much promise for long-term, sustained community development and job creation as the relatively young field of biotechnology. Few states are as well positioned as North Carolina for national and international leadership in biotechnology and economic gain from the industry's growth.

Often described as a single industry, biotechnology more accurately refers to the large and growing array of scientific tools that use living cells and their molecules to make products and solve problems in many different industries. Agriculture, human and animal health care, forestry, the environment, and specialty chemicals are among the industries that have benefited most from biotechnology.

The economic promise of biotechnology is extraordinary. At present a \$40 billion sector worldwide, it is estimated to become a market of at least \$120 billion annually within 10 years. North Carolina companies, already creating about \$3 billion in annual biotechnology revenue, can grow in number, employees, and revenues — if provided the right resources and environment.

The benefits of biotechnology to North Carolina — and the world — are clearly not limited to jobs and other forms of economic development. Biotechnology products are profoundly improving the crops we grow, the food we eat, the medicines we take, the environment in which we live, and the everyday products we use.

A strong foundation

North Carolina has a strong base on which to expand biotechnology science, companies, and economic return. In the early 1980s, visionary State leaders established a structure and a long-term commitment for biotechnology innovation and commercialization. North Carolina recognized early that the science and applications of biotechnology fit remarkably well with its natural resources and economic foundations. A technology based on living organisms is well suited for a place strong in agriculture, native plants, marine resources, forestry, food, pharmaceuticals, and manufacturing. To ensure a coordinated and innovative approach to biotechnology development, the State established the North Carolina Biotechnology Center — the first state-sponsored biotechnology initiative in the United States.

Over the last two decades, the Biotechnology Center has carefully targeted its funding to the requirements of biotechnology development: science and research, education and workforce training, and company establishment and growth. Programs and activities have assisted but not duplicated the efforts of various public and private entities involved in biotechnology, from universities and entrepreneurs to investors and start-up companies. Twenty years of strategic investment have paid off handsomely; North Carolina has deliberately and

Biotechnology Industry
at a Glance, 2002

	United States	North Carolina
Number of companies	1,466	152
Number of employees	194,600	18,500
Revenue	\$33.6 billion	\$3 billion

SOURCE: ERNST & YOUNG, 2003; NC BIOTECHNOLOGY CENTER

Vision

The State will aggressively create jobs, wealth and a better quality of life for all North Carolinians by encouraging biotechnology investments in health care, agriculture, the environment, manufacturing and other strategic growth industries vital to its economy.

successfully stimulated one of the most envied, interactive, and productive biotechnology communities in the world.

North Carolina is one of the leading five states in the U.S. for biotechnology science, commercialization and revenue. With more than 150 companies employing 18,500 workers, North Carolina represents about 10 percent of the U.S. biotechnology industry. In addition, the wider life science industry now includes tens of thousands of other North Carolinians employed in agricultural, pharmaceutical and chemical companies; contract research organizations and laboratory testing companies; professional support firms; and life science-related companies.

A highly competitive sector worldwide

Not surprisingly, the current impact and growing potential of biotechnology have captured the attention of governmental, educational, and economic development leaders worldwide. Benefits from biotechnology are particularly sought by places facing economic challenges due to globalization or decline of traditional industries. Virtually every state in the nation has joined regions and countries worldwide in targeting biotechnology. While not all places will succeed, a challenging number have significant assets and are prepared to make enormous investments in biotechnology research, infrastructure, and company development. And, while many places acknowledge their goal of duplicating North Carolina’s approach and results, their indirect compliment is more alarming than gratifying.

Bold vision and leadership

In the face of intensified worldwide competition, just *maintaining* North Carolina’s current position will require significant commitment and resources. *Strengthening* the state’s biotechnology capability and competitiveness will demand clear vision, aggressive leadership, and greatly expanded investment. The second option is realistically the only one to be considered; otherwise, economic gain and jobs will be lost to competing states and nations.

The biotechnology leadership and commitment demonstrated by North Carolina over the last two decades must be enhanced and expanded to ensure an equally strong third — and fourth — decade of biotechnology development and jobs. Recognizing that vision and risk-taking must shape smart and practical decisions, in June 2003, Governor Easley charged the North Carolina Biotechnology Center and leaders statewide to develop a long-term strategic plan to help guide future State investments in biotechnology. The vision for that plan is for the State to aggressively create jobs, wealth and a better quality of life for all North Carolinians by encouraging biotechnology investments in health care, agriculture, the environment, manufacturing and other strategic growth industries vital to its economy.

Led by the Steering Committee listed on page 3, more than 120 North Carolinians diverse in geography and perspective shared ideas and experience in six content-based work groups: K-12 education, workforce training, building entrepreneurial companies, attracting companies to the state, university research and infrastructure, and public policy and societal considerations. Listed at the end of the document, work group participants included representatives of the

main partners in North Carolina's biotechnology community: state, regional, and local economic developers; private and public universities; community colleges; government agencies; large and small companies; venture capitalists; non-profit organizations such as the Council for Entrepreneurial Development, the North Carolina Biosciences Organization, and the Small Business and Technology Development Center; and various public policy organizations.

Strategic recommendations

Collectively, the work group participants identified 54 strategies necessary to reach the goal of having 48,000 North Carolinians employed in biotechnology-related jobs by 2013 and 125,000 by 2023. Many of these strategies will require large and sustained investment over several years to achieve their intended outcome. Others do not require state investment but do need the commitment and action of various partners across North Carolina's large and well-established biotechnology community.

As summarized in the table at the end of this executive summary, the 54 strategies address the major requirements of a comprehensive biotechnology initiative: creation of knowledge, products and companies; attraction, retention and growth of companies; preparation of current and future workers; development of biotechnology statewide; and leadership, ethical and policy considerations. All 54 strategies are important to meeting the plan's job creation goal and should be implemented as soon as possible. However, based on their contribution to three areas identified as immediate priorities below, a much smaller number of strategies are essential in the first year of the plan, FY 2005.

Immediate priorities

Given the need to create new jobs, and to bring these jobs to all parts of North Carolina, three areas should be considered immediate priorities for the state's biotechnology investments: biomanufacturing; biotechnology start-ups; and statewide development.

1. **Target biomanufacturing:** Biomanufacturing is an ideal industry for North Carolina, not only because it creates clean, high-paying jobs, but also because those jobs can be located in rural North Carolina, where traditional manufacturing jobs are in steep decline. North Carolina already has a strong base of pharmaceutical manufacturing and biomanufacturing on which to grow. With the recent commitment of \$64.5 million by the Golden LEAF and industry to build a statewide workforce training network in biomanufacturing, the State has assured companies already based in North Carolina and those that might come to the state that a supply of well-trained workers will be available. To fully capitalize on this investment, the state should:
 - a. strengthen the recruitment capabilities of the Department of Commerce, with expert staff, marketing resources, appropriate incentives, and authority to match prospects selectively with North Carolina sites;
 - b. create a ready source of financing for biomanufacturing facility construction through credit-enhancing vehicles;
 - c. provide the community colleges with sufficient funding and infrastructure to train and educate workers for this industry.

Goal

North Carolina will have 48,000 biotechnology-related jobs by 2013 and 125,000 by 2023.

Immediate Priority No. 1

Target Biomanufacturing

Immediate Priority No. 2

Create and Attract Biotech Start-ups

2. **Create and attract biotechnology start-up companies:** If the environment is supportive, biotechnology companies tend to emerge and grow near the source of their technology, which is often a university, federal or private research laboratory, or another company. Therefore, the opportunity for long-term, sustainable job creation is strong with “home-grown” biotechnology companies, particularly in North Carolina, which has a well developed and cohesive biotechnology community. To help ensure a steady supply of entrepreneurial biotechnology companies, the State should:
 - a. expand funding for university research, particularly high-risk, early stage applied research, to facilitate a constant flow of new discoveries with future commercial potential;
 - b. use every available mechanism to ensure that young companies have access to the investment capital they require, particularly at the earliest stages of their development. Two potential sources include the Biotechnology Center’s Economic Development Investment Fund and State escheat or pension funds; and
 - c. give greater attention and resources to support the relocation of emerging biotechnology companies from other states and countries to North Carolina.

Immediate Priority No. 3

Develop Biotechnology Statewide

3. **Develop biotechnology statewide:** Biotechnology development in North Carolina does not have to be limited to the technology-rich Triangle and Triad regions. Because of its varied natural resources, including agriculture, forestry and marine life, and its widespread network of higher education resources, North Carolina is uniquely able to develop biotechnology in multiple regions of the state. While the manufacturing jobs associated with biotechnology and other life sciences may represent the best opportunity for economic development in some particularly rural regions, other areas can — and have begun to — capitalize on unique resources and infrastructure to build their own biotechnology communities. These efforts should be supported and nurtured by:
 - a. assisting communities statewide to identify and target resources for building biotechnology-related activities and helping them establish realistic goals for these endeavors; and
 - b. supporting satellite offices of the Biotechnology Center in the East, West, Triad and Charlotte with staff and programmatic resources.

Ensuring prosperity

As regions across the globe struggle with economies in transition, North Carolina is well positioned with early and ongoing commitment to biotechnology — one of the few sectors that will provide long-term economic gain and job growth. Fortunately, in North Carolina the value of the technology is fully granted by governmental, institutional and economic development leaders statewide. Their vision and commitment to the technology will in coming years bring jobs and other benefits critically important to the economy of North Carolina and the quality of life of its people.

Strategies for Growing the Economy Statewide through Biotechnology

The 54 strategies recommended in this plan are designed to:

Enhance the ability of public and private universities across North Carolina to conduct innovative research in biotechnology and transform new ideas into commercial opportunity within the state by:

- Helping them attract and retain talented faculty, post-docs, and graduate students (#1, 2, 3)
- Strengthening their biotechnology research infrastructure and funding regional research centers (#4, 5, 6)
- Supporting high-risk, early-stage applied research projects (#7)
- Providing their technology transfer offices with the resources and flexibility they require — based on individual circumstances — to maximize the economic development potential of university discoveries (#8)
- Encouraging university-industry interactions (#9, 10, 11)

Encourage universities to support, recognize and reward faculty entrepreneurial activities by:

- Clarifying institutional economic development missions (#12)
- Incorporating measures of faculty entrepreneurial activities into promotion and tenure decisions (#13)
- Funding entrepreneurial sabbaticals and creating entrepreneurs-in-residence programs (#14, 15)

Support the creation and growth of biotechnology companies by:

- Increasing the availability of early-stage investment capital (#16, 17, 18, 19)
- Helping them access federal research funding and other resources (#20)
- Providing targeted tax relief (#21)
- Creating programs to help develop successful entrepreneurs (#22, 23)

Support the attraction, retention and growth of biotechnology companies, with particular attention to biomanufacturing companies, by:

- Providing the Department of Commerce with the staff and resources required to aggressively pursue recruitment and retention activities (#24)
- Forging select international partnerships of strategic value to North Carolina (#25)
- Having the Department of Commerce and the Biotechnology Center form a “Hot Opportunities Team” (HOT) to coordinate recruitment of hot prospects and retention of companies at risk of leaving (#26)
- Funding aggressive marketing campaigns to effectively sell the state’s life sciences assets (#27)
- Creating competitive financial incentives (#28, 29, 30)
- Providing financing mechanisms for companies building biomanufacturing plants in the state (#31)
- Addressing the needs of bioscience businesses already in North Carolina (#32)

Help train and educate North Carolinians across the state for jobs in biotechnology research and development and in biomanufacturing by:

- Providing the Community College System with resources to implement biotechnology and biomanufacturing-related programs (#33, 34)
- Ensuring every community college has well equipped science and engineering technology laboratories (#35)
- Providing on-going operational funding to maintain the facilities and programs associated with the Biomanufacturing and Pharmaceutical Training Consortium (#36)
- Providing professional development opportunities for faculty (#37)
- Supporting the development and implementation of industry-approved certification programs, articulation agreements, and innovative curricula (#38, 39, 40, 41)
- Establishing a Biotechnology Workforce Advisory Council to provide industry input to the educational systems (#42)

Strengthen K-12 math and science education to help motivate and prepare future biotechnology workers by:

- Supporting and expanding the North Carolina Infrastructure for Science Education (#43)
- Creating innovative schools for biotechnology using Gates Foundation grant monies (#44)
- Requiring proficiency in inquiry-based science teaching methods for teacher accreditation (#45)
- Providing enhanced opportunities for professional development (#46)
- Supporting the development of innovative curriculum and providing resources for teaching about biotechnology (#47, 48)

Strengthen biotechnology statewide by:

- Assisting communities, particularly rural ones, to identify and build on biotechnology-related resources and capabilities (#49)
- Supporting satellite offices of the Biotechnology Center in the East, West, Triad and Charlotte with staff and programmatic funding (#50)
- Charging the Biotechnology Center with leadership for the state's biotechnology policies and strategies, including the implementation of the strategic plan (#51)
- Informing and engaging state leaders on issues critical to biotechnology development (#52)
- Establishing a forum at the Institute for Emerging Issues to discuss ethical, societal and policy issues related to biotechnology (#53)
- Increasing funding for the Board of Science and Technology (#54)

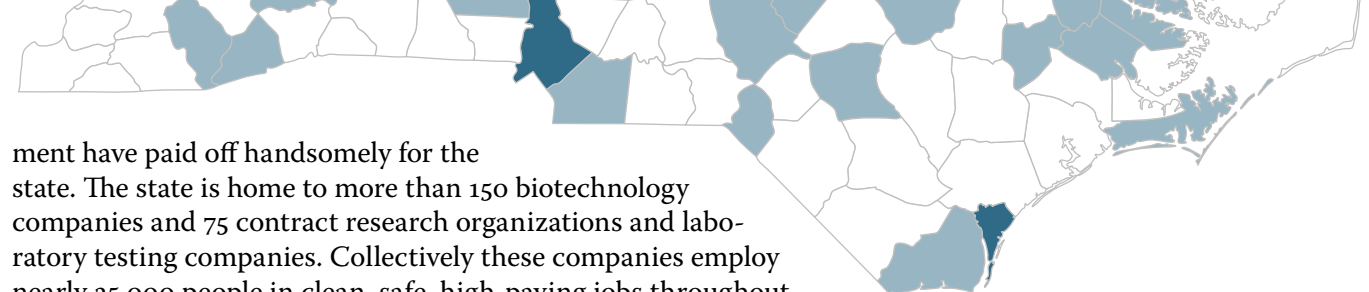
The Case for Biotechnology in North Carolina

North Carolinians have always aspired to a better future. From the first colonial settlers who came ashore seeking freedom and opportunity more than 400 years ago, to the visionaries who are leading the state's advancement in science and technology in the 21st century, North Carolinians have shaped their own destiny with a bold spirit of exploration, innovation, and risk-taking. A tradition of visionary thinking followed by practical action is ingrained in the state's history and culture. It is the formula for progress, and it has improved the lives of all North Carolinians throughout the years. It has given North Carolina the nation's first state-supported university, the first community college system, the first residential high school for science and math, and the world's largest planned science and technology campus, the Research Triangle Park. Today it puts North Carolina on a new frontier of knowledge and job creation: biotechnology.

When scientists conducted the first successful genetic engineering experiments in the mid-1970s, leaders in North Carolina paid attention. They realized that a potent new technology was emerging and that it could bring substantial economic and societal benefits to the state. They looked into the future and saw the tools of biotechnology being put to work in agriculture, forestry, medicine, manufacturing and many other industries vital to North Carolina's economy. Wanting North Carolina to be at the forefront of this promising new industry, the State in 1981 created an organization to stimulate the development of biotechnology. The non-profit North Carolina Biotechnology Center became the world's first government-sponsored initiative dedicated to growing this industry and creating opportunities for North Carolinians.

Early success

North Carolina's early investments in biotechnology develop-



ment have paid off handsomely for the state. The state is home to more than 150 biotechnology companies and 75 contract research organizations and laboratory testing companies. Collectively these companies employ nearly 35,000 people in clean, safe, high-paying jobs throughout the state. Tens of thousands of other North Carolinians work in jobs that directly support the biotechnology industry, providing products and services in architecture, banking, construction, engineering, real estate, utilities, laboratory instrumentation and supplies, information technology, data management, accounting, law, staffing, and many others. Once concentrated

As North Carolina's economy transitions from a labor-intensive manufacturing base, we must foster job creation in sustainable, knowledge-driven sectors. With products in agriculture, forestry, health care, and the environment, biotechnology is a natural fit for North Carolina offering a strategic opportunity that builds on our strengths.

— SECRETARY JAMES T. FAIN III,
NORTH CAROLINA
DEPARTMENT OF COMMERCE

Bioscience companies in North Carolina

- 7+ biotech companies
- 1-6 biotech companies
- 0 biotech companies

SOURCE: NORTH CAROLINA BIOTECHNOLOGY CENTER

North Carolina's model for biotechnology development

Established by the State in 1981, the North Carolina Biotechnology Center is the world's first government-sponsored initiative in biotechnology development. Its mission is to provide long-term economic and societal benefits to North Carolina by supporting biotechnology research, business and education statewide.

As a neutral, non-partisan, non-profit organization, the Center is uniquely positioned to work effectively with government, industry, academia and other organizations. The Center works in partnership with the North Carolina Department of Commerce, the North Carolina Biosciences Organization, the Council for Entrepreneurial Development, the UNC System, private universities, the Community College System, the Small Business and Technology Development Center, the Golden LEAF, chambers of commerce and many other groups and elected officials to achieve **six goals**:

- 1. Strengthen North Carolina's academic and industrial biotechnology research capabilities.**
- 2. Foster North Carolina's biotechnology industrial development.**
- 3. Work with business, government and academia to move biotechnology from research to commercialization in North Carolina.**
- 4. Inform North Carolinians about the science, applications, benefits and issues of biotechnology.**
- 5. Enhance the teaching and workforce-training capabilities of North Carolina's educational institutions.**
- 6. Establish North Carolina as a preeminent international location for the biotechnology industry.**



With the help of its working partners and the financial support of the General Assembly, the Center has made targeted investments in biotechnology that have been leveraged into substantial gains for the state. Selected accomplishments include:

- Providing \$10.6 million in financial assistance to 70 early stage biotechnology companies, which have gone on to raise more than \$500 million from other sources.
- Working to recruit, retain and expand biotechnology companies including BASF, Bayer, Biogen Idec, Diosynth RTP, KBI BioPharma, Novozymes, Schwarz BioSciences, Syngenta and Wyeth Vaccines, collectively responsible for thousands of high-paying jobs.
- Investing more than \$50 million to recruit 46 outstanding faculty, purchase multi-user research equipment, and sponsor more than 450 research projects at North Carolina universities. For every \$1 invested in research projects by the Biotechnology Center, the universities have gained about \$14 in federal grants.
- Preparing more than 1,100 teachers in North Carolina to teach about biotechnology. In turn, they have given lessons and labs to hundreds of thousands of students.
- Tripling enrollment in the biosciences at the state's six historically minority universities by granting \$8 million in special appropriations to improve the institutions' biotechnology programs.

largely in the Research Triangle region, biotechnology companies are emerging in the Triad, the West, Charlotte and the East. Building on their unique natural resources, university capabilities and community college training programs, these regions are beginning to focus on niche areas of biotechnology that have the opportunity to yield economic and societal benefits for their population.

In 1981 there was also a notable absence of competition for biotechnology jobs from other states and nations. The term “biotechnology” had barely begun to be used in common language. Other than the most visionary leaders, such as those found in North Carolina and a few other states, no one had recognized that this emerging technology would one day be considered by virtually every state and every developed nation as critical to its success in the knowledge-based economy. Today, many states and countries, particularly those very new to biotechnology, are attempting to replicate at least parts of North Carolina’s model for developing this young but rapidly growing industry. They have seen North Carolina become one of the top five states in the nation for biotechnology revenue and jobs, and they are striving to take its place. With a current U.S. market of \$33.6 billion and projections of a global market of well over a hundred billion dollars within 10 years, who can blame them?

Through its early and sustained commitment to biotechnology, North Carolina now accounts for 10 percent of the U.S. market as measured by jobs, revenue and number of companies. In the face of unprecedented global competition for the high-wage jobs associated with biotechnology, however, the state cannot and should not be complacent about its opportunities for future success. Once considered the leading role model for biotechnology economic development, North Carolina now finds itself studying daily announcements of creative new programs and enormous investments by competitive regions seeking to create, attract and grow biotechnology and biomanufacturing companies. A few examples are highlighted in the table on page 20.

North Carolina must recognize the challenge and be prepared to invest, especially in an era of rapid change and uncertainty. The state’s economy is in transition. Jobs in traditional industries such as tobacco, textiles and furniture are being lost to cheap foreign labor, free trade policies and other market forces. How will North Carolina replace these jobs? Where will its people go to work, and what will they do? How will North Carolina com-

In high cotton: biotech crop rejuvenates farming in Eastern North Carolina

Milton Prince of Belhaven was accustomed to growing corn, wheat and soybeans on his Beaufort County farm since the 1970s. But when American consumers turned from synthetic clothing to natural fibers in the 1980s, he added cotton to the mix.

He started on a small scale in 1991, but the rich, dark soil — known as the Black Lands — had other ideas. It sprouted cocklebur, morning glory, pigweed, sicklepod, smartweed and other weeds that overtook the cotton, stunting his crop yields.



PHOTO BY BILL SANDIFER

“Without biotechnology, cotton would not be grown in this area today — no question about it,” says Milton Prince.

“I fought that thing for four years,” Prince recalled. “I was about to throw in the towel. We really had no herbicides to control weed pressures.”

Then along came new cotton varieties genetically engineered to resist herbicides. Growers could apply herbicides that would kill the weeds but spare the cotton plants. It was a revolutionary advance for growers like Prince.

“These genetically engineered cultivars gave us the opportunity to grow cotton and control weeds effectively,” he said. “Without biotechnology, cotton would not be grown in this area today — no question about it.”

Today, about 50,000 acres of biotech cotton is grown in Beaufort County and neighboring Hyde, Tyrrell and Washington counties, a 50-fold increase from the 1,000 acres grown in 1991. Biotech cotton has become so profitable that Prince no longer grows soybeans and other crops. All of his 2,700 acres are planted with biotech cotton that resists the environmentally friendly but broadly effective herbicide Roundup.

To process all the locally grown biotech cotton, Prince and nine other growers joined together in the late 1990s to build two cotton gins — one in Beaufort County and one in Hyde County. The \$10 million investment in Coastal Carolina Cotton Gins has boosted the tax base of both counties and created 10 full-time jobs and another 48 seasonal jobs.

...it's important to remember that biotech is the one industry that's poised to grapple with every major human and environmental challenge from global hunger to global warming.... This is an extraordinary industry which is characterized by long timetables and high financial risk. But investment in biotech is not just about money, it's about humanity, health, and the preservation of the planet."

— G. STEVEN BURRILL, BIOTECH 2003: LIFE SCIENCES: REVALUATION AND RESTRUCTURING. 17TH ANNUAL REPORT ON THE INDUSTRY.

pete in the new global economy? How will it distinguish itself from other states and nations? These questions are central to the state's future. The answers must include biotechnology.

Biotechnology: many tools for many industries

What exactly is biotechnology? Breaking down the term into its parts provides the answer. "Bio" means living, and "technology" means the use of science to achieve a practical purpose. Biotechnology, then, is broadly defined as the use of living cells and their molecules to make products and solve problems.

It is important to recognize that biotechnology is not an industry unto itself. Rather, it is a collection of new tools that can be used to improve a wide variety of traditional industries including plant and animal agriculture, health care, the environment, industrial processing, household products, forensics, forestry, textiles and biodefense. Virtually every aspect of our lives is touched in some way by biotechnology: the food we eat, the water we drink, the air we breathe, the clothes we wear, the pets we keep, the detergents we use, the medicines we take, the paper we write on, and even the criminals we convict through DNA forensics.

In health care, for example, more than 325 million people worldwide have been helped by 155 biotechnology drugs and vaccines approved by the U.S. Food and Drug Administration. Hundreds of diagnostic tests are on the market to help detect and monitor various diseases and health conditions, ranging from cancer to pregnancy to strep throat. In agriculture, a majority of the U.S. soybean and cotton crops are bioengineered for either insect resistance or herbicide tolerance, providing greater yields with less use of chemical pesticides. In industrial processing, enzymes capable of withstanding high temperature and pressure are used in the chemical, food and textile industries.

Biotechnology is a powerful tool set. Used responsibly, these tools can revitalize traditional industries, create jobs, improve our economy and enhance our quality of life.

Opportunities in biotechnology and biomanufacturing

In the last 10 years, biotechnology employment has more than doubled and revenues have quadrupled in the United States. Biotechnology is now a \$33.6 billion industry in the United States and employs 194,600 people at 1,466 companies. Biotechnology has also grown at a similar pace in North Carolina. The state accounts for about 10 percent of the U.S. industry.

Despite this growth, the biotechnology industry is relatively young. It is at a point where the computer industry was in the 1970s: on the verge of explosive growth. The economic opportunities that lie ahead in biotechnology will eclipse those realized to date. Global sales are expected to reach \$120 billion per year by 2013. In the same period, U.S. sales are projected to double to \$66 billion. If North Carolina's biotechnology industry continues to grow at its traditional rate of about 10 percent a year, it will employ 48,000 people and earn annual revenues of \$7.7 billion by 2013. And by 2023, more than 125,000 North Carolinians will be employed in a \$24 billion industry statewide.

Clearly, great economic benefits await states, regions and nations that are prepared to seize the opportunities in biotechnology. But what exactly will those opportunities be? Name just about any industry, and opportunities can be found: health care, agriculture, functional foods, nutraceuticals, forestry, marine resources, the environment,

industrial processing, biodefense and bio-informatics. One day biotechnology will be as pervasive and essential a tool as plastics or computers are today.

One particularly compelling opportunity for North Carolina is biomanufacturing, or the making of biological products from living cells. There simply is not enough biomanufacturing capacity worldwide to make the biotech drugs, vaccines and other products

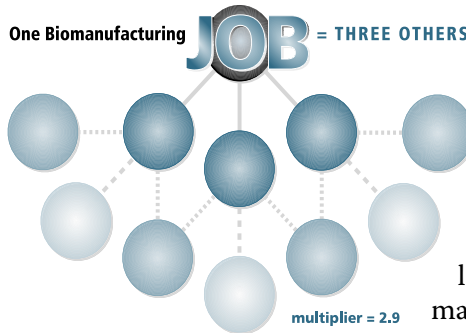
coming to market. In addition to the 155 biotech drugs and vaccines already on the market in the United States, another 370 are being tested for possible approval by the Food and Drug Administration. Worldwide, more than 1,000 biopharmaceuticals are in the development pipeline. Some projections indicate that by 2006 the world could have only half the biomanufacturing capacity it needs. Clearly, new biomanufacturing plants must be built in the next few years to meet the growing demand.

High-paying jobs await those regions and states that can attract these new plants. Annual salaries for entry-level technicians typically start at \$25,000 to \$30,000 and can progress to \$50,000 in as little as five years. The average salary for all pharmaceutical manufacturing jobs in North Carolina is \$68,200.

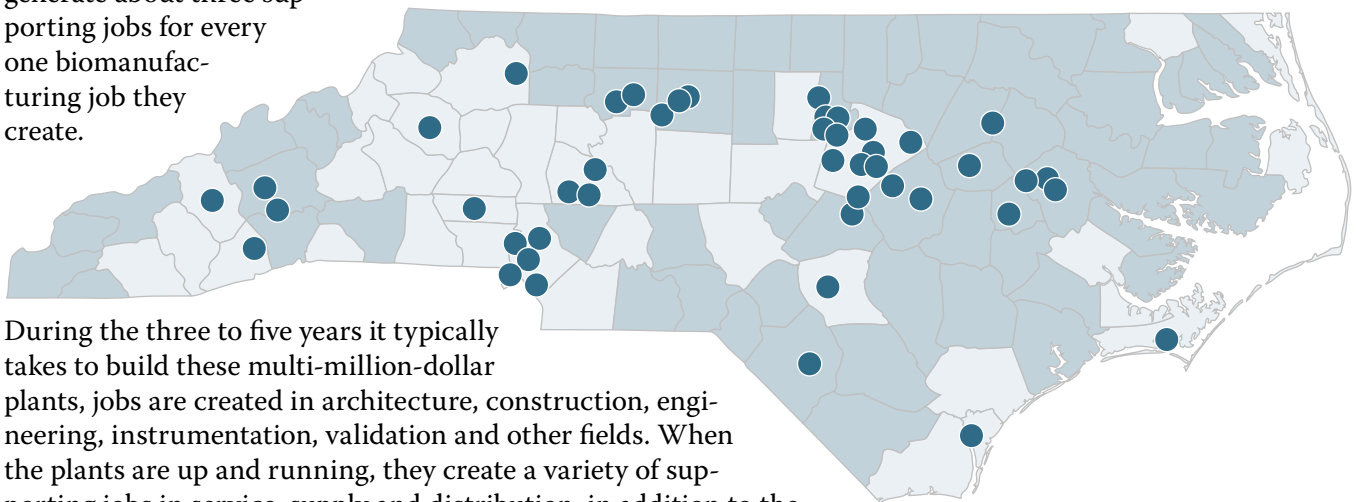
Biomanufacturing plants also generate about three supporting jobs for every one biomanufacturing job they create.

During the three to five years it typically takes to build these multi-million-dollar plants, jobs are created in architecture, construction, engineering, instrumentation, validation and other fields. When the plants are up and running, they create a variety of supporting jobs in service, supply and distribution, in addition to the many indirect jobs and economic activity created in housing, transportation, retail, utilities, entertainment, etc.

Biomanufacturing is an ideal industry for North Carolina, not only because it creates clean, high-paying jobs, but also because those jobs can be located in rural North Carolina, where traditional manufacturing jobs are in steep decline. And while no jobs are ever 100 percent secure, biomanufacturing jobs



Biomanufacturing and Pharmaceutical Manufacturing Plants in North Carolina



- Manufacturing sites
- Tobacco-dependent counties

The Case for Biotechnology in North Carolina

Examples of government funding for biotechnology

State	Program	Purpose	Financial commitment
California	Biotechnology Research and Education Program	support biotechnology research	\$20 million since 1985
Florida	Scripps Research Institute	recruit Scripps Research Institute to Palm Beach County	\$510 million committed in October 2003 (\$310 from state; \$200 million from county)
	Florida Biomedical Research Program	fund biomedical research	\$41 million since 2000 *
Georgia	Eminent Scholars Program	recruit eminent scholars	\$350 million since 1990
Iowa	Grow Iowa Values Fund	primarily to support economic development in biotechnology, information services and applied manufacturing businesses	\$503 million over 7 years
Kentucky	Research Challenge Trust Fund	recruit and support research scholars	\$350 million since 1998
Maryland	University of Maryland Biotechnology Institute	expand the Rockville research campus	\$50 million in 2003
Michigan	Life Science Corridor	fund basic and applied life sciences research	\$25 million in 2004 (was previously \$50 million per year) *
Missouri	Life Sciences Trust Fund	support biotechnology research, commercialization and technology transfer	\$36 million per year beginning in 2007
Pennsylvania	Life Science Greenhouses	fund three regional life science business "greenhouses"	\$100 million in 2001 *
Texas	Cow Genome Project	sequence the cow genome	state to contribute \$10 million to \$50 million project
	Texas Enterprise Fund	recruit technology businesses and support university research	\$55 million in 2003

Country		Purpose	Financial commitment
Canada (Ontario)	Biotechnology Cluster Innovation Program	support commercialization infrastructure projects	\$30 million
China		support biotechnology research	\$180 million between 1996 and 2000; expected to spend \$600 million between 2000 and 2005
India		various biotechnology initiatives	\$2.3 billion
Ireland	Science Foundation Ireland	recruit and retain biotech and IT scholars	\$745 million between 2000 and 2006
	public-private partnership between Enterprise Ireland and Seroba BioVentures	fund to boost biotech company start-ups and employment	\$29 million
Singapore	Biopolis	create a global hub for biomedical sciences	\$1.7 billion

* TOBACCO SETTLEMENT FUNDS

are less likely to go offshore than are traditional manufacturing jobs. They are highly technical jobs in a tightly regulated industry. Not every state or nation has the ability to build, staff and supply these sophisticated plants in compliance with the FDA's stringent requirements.

North Carolina is already a national leader in biomanufacturing, employing 4,700 people in the manufacture of drugs, vaccines, amino acids, enzymes and vitamins. Employment swells to nearly 25,000 people if the closely related traditional pharmaceutical manufacturing industry is included.

In addition to its high ranking in biomanufacturing, North Carolina is the world's leading place for the contract research organization (CRO) and testing industry. CROs emerged in the last two decades to help pharmaceutical and biotechnology companies get their products to market faster and cheaper. CROs and related testing companies help drug- and device-makers test their products in animals and people by managing clinical trials, collecting and analyzing data, helping navigate the FDA-approval process and providing many other services.

More than 75 CRO companies operate in the state, employing 16,000 North Carolinians and tens of thousands of people worldwide. Some of the world's largest CROs were founded in North Carolina or have their headquarters in the state.

The strong presence of both biomanufacturing and CRO companies in North Carolina, coupled with a strong environment for research and development, provides biotechnology companies a complete range of capabilities. Companies can research, develop, test and manufacture their products without ever leaving the state.

Competitive challenges

Because the opportunities in biotechnology are so compelling, governments across the country and around the world are pursuing biotechnology aggressively to drive economic development. A few of those initiatives are highlighted in the table on page 20.

More than 40 states have followed North Carolina's lead and developed biotechnology initiatives of their own. At least 10 states have created strategic plans for the life sciences in the last five years; and many are outspending North Carolina, often with proceeds from the federal tobacco settlement. At least 16 states are using tobacco settlement money to fund bioscience research and development. However, some states are scaling back their previous commitments to biotechnology as the economy has weakened and their budget deficits have worsened.

Virtually every state is a competitor to North Carolina, including those that have not traditionally been strong in biotechnology. Virginia, though not ranked among the top dozen biotech states, landed a \$425 million insulin-manufacturing plant in 2002 that will create 700 jobs. Eli Lilly chose Virginia because it provided more than \$5 million in grants plus workforce training services and road improvements. Likewise, Florida, which has a modest life sciences industry not ranked in the top 12 states, will invest \$310 million in state funds to recruit the Scripps Research Institute to West Palm Beach. Palm Beach County is investing an additional \$200 million to provide a total incentive package of \$510

"...other regions across the country and around the globe have been moving up fast in our rear view mirror.... What is crucial now for North Carolina is a serious assessment of what makes sense for the state's future in a radically changed global economy that is increasingly driven by innovation."

— *Jump Starting Innovation*
THE INSTITUTE FOR EMERGING
ISSUES 2003.

The Case for Biotechnology in North Carolina

million. During the next 15 years, Scripps Florida hopes to create 6,500 jobs, and help attract another 40,000 jobs in pharmaceutical manufacturing and related industries that often locate near such research centers.

As biotechnology increasingly becomes a global business, North Carolina also faces rising competition from other countries. Dozens of nations are investing heavily in biotechnology and enacting policies favorable to the industry's growth. North Carolina needs to anticipate where the biotechnology industry is going, determine what it requires, and provide the right environment for its growth before competing states and nations do.

A Plan to Grow the Economy through Biotechnology

If North Carolina is to have 48,000 biotechnology-related jobs by 2013 and 125,000 by 2023, it requires a strategic plan. The plan will enable the State to aggressively create jobs, wealth and a better quality of life for all North Carolinians by encouraging biotechnology investments in health care, agriculture, the environment, manufacturing and other strategic growth industries vital to its economy. It must also address all the elements vital to biotechnology development: globally competitive university research; innovative and aggressive technology transfer; a well-trained workforce; an excellent K-12 education system; business-friendly government policies; strong leadership; plentiful investment capital; statewide commitment; and a culture that supports visionary thinking, risk-taking and entrepreneurship. Given the current economy and the need for new jobs, the plan should emphasize job creation.

There are two ways to create jobs in biotechnology: start and grow companies within the state, and attract companies from outside and help them grow. North Carolina has always pursued both and should continue with that strategy, focusing on all areas of the state: east and west, north and south, urban and rural.

STRENGTHEN BIOTECHNOLOGY STATEWIDE

JOBS

CREATE

- Generate new ideas
- Move ideas to market
- Start and grow companies

ATTRACT

- Recruit, grow, and retain companies

EDUCATE

- Train the workforce
- Strengthen K-12 math and science

Create jobs

Three actions are vital to creating jobs within the state: generate new ideas; move ideas to market; and start and grow companies.

Generate new ideas

Because the biotechnology industry is based on new knowledge and research, it naturally clusters around excellent universities. North Carolina has world-class public and private universities.

These public and private research institutions are the foundation for North Carolina's biotechnology industry, and the state, through the North Carolina Biotechnology Center, has invested more than \$50 million over two decades to

'Wonder drug' credited with saving retired professor from paralyzing illness

Everett Nichols of Raleigh woke up one morning in 1998 with numbness in his fingers, hands and toes. By that afternoon he couldn't get out of his car or walk unassisted. He awoke the next morning in a hospital bed, weak, unable to speak, and in great pain and discomfort.



EVERETT NICHOLS

He had contracted Guillain-Barre Syndrome, a mysterious inflammatory disease that attacks the body's peripheral nervous system, causing rapid paralysis.

Nichols, a retired North Carolina State University professor of economics and business, was placed in intensive care and put on a respirator that forced air into his paralyzed lungs. The only way he could communicate was by fluttering his eyelids. "It was a pretty scary thing," he recalled.

Said his son Jim: "There were times when we weren't sure he would make it."

Doctors gave Nichols a product made in North Carolina called Gamimune® N, Immune Globulin Intravenous (Human), 10%, a mixture of antibodies purified from human blood plasma.

"It's a great medication," Nichols said. "It's kind of a wonder drug."

"I really credit it with saving his life," echoed his son Jim. "I'm very grateful to the biotechnology industry."

Thanks to Gamimune®, Nichols' condition stabilized, and he was released from the hospital after three weeks. An additional two weeks of rehabilitation helped his body regain its function. "I was truly blessed and have recovered almost fully," he said.

Today, the 74-year-old Nichols is in good health and leads an active life with his wife, Jean, and their four children and four grandchildren. He heads a local support group for Guillain-Barre Syndrome patients and their families and also volunteers at the Rex Cancer Center in Raleigh.

Gamimune® is made in Clayton, N.C., by Bayer Biological Products at the world's largest blood plasma products plant. The 1,400-employee operation processes donated blood from thousands of people and harvests its life-saving components for the treatment of a wide range of infections and immune disorders.

enhance university capacity for biotechnology research and education. More than 4,000 faculty and technicians at these institutions pursue new ideas, create new technologies, start new companies, educate future teachers and researchers, train students, and advise companies on scientific and technical challenges in the life sciences. North Carolina's universities are competitive in the life sciences.

However, our universities have key needs that must be addressed — even during difficult economic times — if they are to generate enough new ideas to drive the biotechnology industry. Without adequate support, the universities will quickly lose ground in the intense competition with other states and nations. Recruiting world-class bioscience faculty and graduate students to North Carolina is becoming difficult due to competition and insufficient funding. Biotechnology research depends on a strong statewide infrastructure of scientific equipment, instrumentation, specialized research centers, and information technology resources, and North Carolina's scientists need up-to-date tools to compete. North Carolina should also directly fund innovative, high-risk research with commercial potential today so it can reap the economic benefits tomorrow.

Move ideas to market

Generating new ideas is only the beginning of the university's role in biotechnology economic development. Universities directly affect economic development as they transfer ideas from the research laboratory into the market, a process known as technology transfer. Different universities have different scientists, different research specialties, and different approaches to technology transfer. However, all their strategies are affected by resource constraints in the university as well as the larger financial environment in which they operate.

The role of the universities in economic development is broader than technology transfer alone. Connections between universities and industries on many different levels are beneficial, including

formal collaborations such as Millennium-type campuses, interactions with local economic developers involved in recruiting companies, and interactions on course development and faculty recruitment. University business schools also play an important role in training entrepreneurs.

North Carolina is fortunate that its university leaders take economic development seriously. North Carolina universities will continue to create new job opportunities for North Carolinians. Still, the big role that universities play in economic development may not be clear to all parties both inside and outside the universities, since it is not a formal part of their mission statements.

Start and grow companies

Start-up biotechnology companies are valuable to the economy because they typically stay in state, grow rapidly and create an entrepreneurial culture that attracts larger companies.

In addition to intellectual property, entrepreneurial talent and venture capital are vital to starting and growing new companies and creating jobs. North Carolina provides a supportive climate for entrepreneurship and venture capital through several organizations. The non-profit Council for Entrepreneurial Development in Research Triangle Park is the nation's largest business-support group of its kind with more than 4,000 active members representing 1,100 companies. It supports entrepreneurs with programs and services in education, capital formation, mentoring and communications. The Biotechnology Center provides funding, networking, venture capital connections and assistance to companies. Several other organizations encourage entrepreneurship and capital creation, including the North Carolina Biosciences Organization, the North Carolina Electronics and Information Technologies Association, the University of North Carolina Small Business and Technology Development Center and several regional councils for entrepreneurial development.

Although North Carolina has more life science entrepreneurs and venture capital companies than ever, it remains far short of both assets. More early stage capital is needed to move young companies from start-up to adolescence so they can attract sufficient capital for product development and commercialization. The importance of available venture capital at all stages of a company's life cannot be overestimated. As documented in the Brookings Institution's *Signs of Life* report, which includes North Carolina's Research Triangle region, the country's nine most developed biotech hubs have, on average, 30 times more venture capital than do other metro areas. North Carolina also needs more biotechnology executives who can take a company from start-up to commercial success. Otherwise, good technologies and jobs will die on the vine for lack of capable management.

Attract jobs

North Carolina competes with many other states and nations to attract company headquarters and research and production facilities. Its numerous life science and contract research organizations, academic research expertise, supportive infrastructure, and reasonable cost of doing business are tremendous strengths in drawing biotechnology companies to the state. North Carolina's high quality of life is also an important factor in attracting biotechnology companies. People from all over the world want to live and work in North Carolina.

Biotechnology companies preparing to manufacture products are impressed by North Carolina's workforce training programs. The \$60 million Golden LEAF commitment to train biomanufacturing workers, coupled with up to \$4.5 million from industry, is a visionary leap forward and is expected to attract companies to the state. North Carolina State University will receive \$36 million to build

and equip a pilot-scale biomanufacturing plant on its Centennial Campus. North Carolina Central University will receive \$19.1 million to build a Bioprocessing Research Institute and Technology Enterprise and to develop graduate and undergraduate degree programs. The Community College System will receive \$9.4 million to provide specialized workforce education and training across the state.

However, several key needs must be addressed before North Carolina can achieve its great potential for company recruitment. First, North Carolina cannot compete on a level playing field with regions that offer major financial incentives and other forms of corporate assistance. Despite its many competitive advantages, North Carolina needs a greater commitment to company finance, development incentives, and state tax policies that other states have embraced. Second, biotechnology and biomanufacturing companies typically have complex and unique infrastructure requirements. Recruitment efforts should identify the needs of the company being recruited and address them with the appropriate strategic benefits. A coordinated approach to providing these benefits through the North Carolina Department of Commerce is critical. Third, the Department of Commerce needs greater staff and financial resources to coordinate even more aggressive and proactive recruitment campaigns.

Educate

North Carolina's two-pronged approach to biotechnology job creation — create and attract companies — can work only if there is a strong supporting foundation of trained workers, teachers and researchers, and excellent K-12 science and math education.

Train the workforce

Biotechnology is not just a set of tools for research; it is also employed in product manufacturing. The growth of biotechnology from research to large-scale manufacturing has important implications for the number and types of jobs created. First, the total number of employees increases as a company moves from research and development to commercial-scale manufacturing. Second, while research requires more Ph.D.s, manufacturing employs many workers with community college degrees or certificates, or those with high school diplomas and appropriate manufacturing or military experience.

North Carolina has unmatched strengths in the ability to train a biotechnology manufacturing workforce. The nation's first and most extensive community college system is already committed to biotechnology training. Anywhere in the state, citizens are never more than a 30-minute drive away from a community college, where they can receive hands-on training targeted to the needs of local employers. In addition, the Community College System's New and Expanding Industry Training (NEIT) Program provides not only customized training for employees of new biomanufacturing companies, but ongoing customized training for those companies as they add jobs in the future. The community colleges were vital to the state's transition from a low-wage agrarian economy to a manufacturing economy in the latter half of the 20th century, and they can play an enormous role in the state's transition to knowledge-based industries such as biotechnology in the 21st century.

The Biotechnology Center has partnered with industry and the North Carolina Community College System to develop the *BioWork* course for training entry-level biomanufacturing technicians and to provide continuing education for industrial employees.

These assets are not enough to ensure a highly trained biotechnology workforce. The state should address several challenges if it is to prepare a workforce to support both R&D and biomanufacturing.

New and experienced employees in biomanufacturing need access to continuing education and training at the community college level to build on their skills and adapt to the changing needs of their employers. Community colleges must have adequate resources to meet these needs.

At the baccalaureate and higher level, job applicants may know the scientific theory behind biotechnology, but they often don't possess the practical skills needed to work in biotechnology R&D, biomanufacturing, and related pharmaceutical manufacturing. In 2002 North Carolina pharmaceutical companies filled less than 15 percent of entry-level job openings with new college graduates because those graduates lacked experience and practical skills such as teamwork, project management, problem-solving, and oral and written communication. Educators at all levels often do not have a good grasp of the industrial workplace and the skills their students need to succeed on the job.

Although many educational programs provide at least part of the required background for new employees in pharmaceutical or biopharmaceutical manufacturing, few, if any, provide the complete package. There is a strong need to establish comprehensive and targeted training programs at educational institutions across the state.

Strengthen K-12 math and science

North Carolina has made tremendous strides in education in the last two decades, due to strong leadership, investments in schools, and innovative reforms. Yet, many challenges remain, particularly in science and math, if North Carolina's next generation is to be prepared for careers in biotechnology and other knowledge-based industries. North Carolina eighth graders rank only 23rd nationally in science performance on National Assessment of Educational Progress tests. Achievement by minority students on math and science tests lags significantly. Unless test scores improve, North Carolina will be challenged to meet the high standards of the new federal No Child Left Behind Act.

In today's high-technology world, all North Carolinians — but especially parents, students, teachers, school administrators, business and local government leaders — must understand that a solid scientific foundation can open the door to job opportunities in biotechnology for people at all educational levels. But science is often taught with an approach that appeals only to a certain subset of students, and science careers are frequently not promoted as viable options to a broad segment of the student population. Many students are unaware of the different kinds of jobs in biotechnology and the skills required to succeed. Math and science education must begin early, but too little emphasis is placed on science education in grades K-8.

Envisioning North Carolina's biotech future

Picture this: A laid-off textile worker gets community college training for a high-paying job making poultry vaccines at a new biomanufacturing plant in Laurinburg. Three of his neighbors land jobs in packaging, distribution and electrical contracting to support the plant's operations. Meanwhile, a farmer in Bertie County grows sweet potatoes genetically altered to produce more bio-ethanol as a fuel additive. A physician in Charlotte practices "personalized medicine," prescribing drugs and doses that work best for each of his patients based on their unique genetic makeup. A pine plantation in Craven County provides a paper mill with genetically altered trees that require less chemical bleaching. University and company researchers in Winston-Salem collaborate on a federal grant to find a treatment for Alzheimer's disease. In Boone a small company extracts natural medicines and nutritional supplements from native plants found nowhere else on earth but in the Appalachian mountains. And in the port of Wilmington a cargo ship cleans its oily bilge water with a bacterial system before discharging it into the Cape Fear River.

So much is possible throughout North Carolina if the state builds on its investments in biotechnology development.

North Carolina must overcome a shortage of qualified math and science teachers. It attracts too few teachers into these fields and has difficulty retaining them. Teachers often do not know enough about the science they teach, and how best to teach it with an inquiry-based hands-on approach. Too often their schools — especially the poorer rural schools — lack equipment and supplies for teaching math and science.

Strengthen biotechnology statewide

Biotechnology will be increasingly important to the future of all North Carolinians. Its impact will be seen in the economy through new jobs, new companies and new applications for existing industries. Biotechnology will also affect community development, as leaders and institutions apply it to their economic planning, schools, agricultural sectors, health care industries, and long-term goals. In North Carolina biotechnology already has pervasive impact throughout society, affecting science and research, investment and economic development, education and training, agriculture, manufacturing, institutions of higher education, government agencies, and industry. Bioscience companies are located in 36 counties across the state, as shown on the map on page 15.

Few undertakings will be as important to society in coming decades as biotechnology. None is likely to yield such a complicated mixture of policy, economic benefit, required resources and societal issues. Therefore, biotechnology requires informed, sustained and high-level attention statewide.

Strategies, planning and vision for North Carolina's third decade of biotechnology development must be shaped by three broad imperatives:

- *Statewide development and application of biotechnology.* The benefits of biotechnology must be brought as much as possible to all citizens and communities across North Carolina: urban and rural, rich and poor, east and west, north and south, minority and non-minority.
- *Informed and strong leadership.* Success in biotechnology, as with any endeavor important to society, depends on strong leadership by all who govern the state and manage its institutions.
- *Attention to societal and ethical issues.* Addressing the significant ethical, societal and policy issues of biotechnology is not only a societal responsibility, but an opportunity for North Carolina to display practical leadership.

Moving forward

As North Carolina enters its third decade in biotechnology, it is confronted with opportunity and challenge.

The opportunity is great. The uses of biotechnology in health care, agriculture, defense, forestry, specialty chemicals, and many other industries are growing daily. Spending on biotechnology will accelerate in the years to come. Given that biotechnology is largely where information technology was 25 years ago, with most of its major applications not yet imagined, estimates of a global market in excess of \$100 billion within 10 years may well be conservative. Explosive growth will bring explosive opportunity, particularly in new, high-paying jobs.

The challenge is equally great. In the global economy, competition for those jobs is already fierce. Maintaining the status quo in biotechnology development will be tantamount to moving backwards as other states and nations

become more desperate and aggressive in their pursuit of jobs to replace those that have been lost through globalization.

Fortunately, two decades of sustained attention and investment have given the state a strong base of assets for future growth. In addition, unlike most of its recent competition, North Carolina understands exactly what it takes to create biotechnology jobs and to prepare workers for them, from the technicians to the research scientists. More importantly, it is prepared to make the strategic investments required to keep moving ahead, as was recently demonstrated by the commitment of \$60 million by the Golden LEAF to help fund a statewide network to train biomanufacturing workers at all levels, from post-high school through Ph.D.

Another unique attribute of North Carolina is its cohesive and collaborative biotechnology community. Partnerships between the community colleges, public and private universities, government agencies and industry are common and have yielded great success, such as the training network, which has been an industry-led initiative.

Where North Carolina should continue investing and how much is the subject of the remainder of this plan. With an economy in transition and workers being laid off from the state's traditional industries of tobacco, textiles and furniture in record numbers, new job creation is the primary concern. Therefore, the plan is written with job creation as the underlying goal and is approached through seven required tasks:

Create

1. Generate New Ideas
2. Move Ideas to Market
3. Start and Grow Companies

Attract

4. Recruit and Grow Companies

Educate

5. Train the Workforce
6. Strengthen K-12 Math and Science

Strengthen

7. Strengthen Biotechnology Statewide

Implementation of the strategies

Each of these seven areas of attention is discussed in its own chapter, with relevant strategies presented in a table at the end of the chapter.

The table that begins on page 86, *New Jobs Across North Carolina: Moving Forward*, identifies for all 54 recommended strategies the implementation timetable, required investment, responsible parties, and ways of measuring success. The investment figures are preliminary estimates that will be revised as strategies are refined. In all cases, the investments listed represent *new* dollars, over and above current funding levels of designated institutions or agencies.



Generate New Ideas

Generating new ideas that can eventually lead to new companies and jobs is essential for North Carolina's economic prosperity. University research is the primary source of these new ideas — it is the engine that drives innovative new businesses and job creation. The most immediate payoff comes from applied research, but even basic research can ultimately lead to commercial products.

Productive research requires talent, well-equipped laboratories and computing resources, and substantial federal funding. In the competition for federal funding, success breeds success — talented researchers with the equipment to do the job tend to obtain more grants, which in turn support more successful research. But there's a catch. Most federal research funding is for specific projects. There is none to support recruiting talent, and the competition for the limited number of grants to set up major new laboratories with the latest equipment is intense. Other sources of funding are needed to fill these crucial gaps.

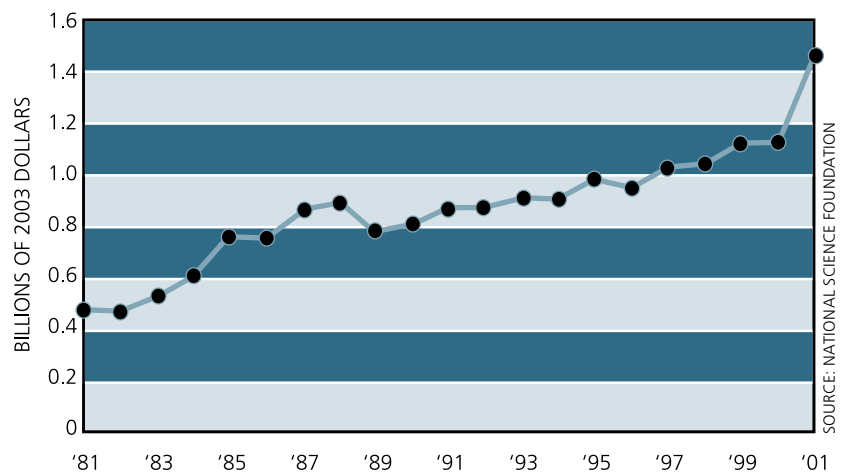
State leaders years ago understood this, and invested in building the universities' capacity for research through a series of Biotechnology Center grant programs. This early vision paid off. Today, more than 4,000 faculty and technicians conduct research in the life sciences at North Carolina's public and private colleges and universities. Each year, these institutions, as well as federal laboratories and non-profit institutes, conduct more than \$1.5 billion of sponsored research in the life sciences, placing North Carolina among the top five states in the nation. State investments in research equipment, faculty and high-risk projects through Biotechnology Center grants have helped public and private universities across the state compete more successfully for federal research funding. These investments were an important contributor to the increase in federal funding to North Carolina institutions from 1981 to 2001, shown on the adjacent chart.

But competition for federal research funds is heated. Today the top research states are devoting significant state resources to life sciences research. Seven states are ahead of North Carolina in per capita funding for medical research from the National Institutes of Health, as indicated in the table on page 34. Unfortunately, due to substantially reduced appropriations in the last few years, the Biotechnology Center has not been able to maintain its funding for university research projects anywhere close to historically high levels. Now is the time for a renewed commitment

"In the new economy, science, technology and innovation are the keys to successful economic development."

— THE SECOND CORNERSTONE, INVEST IN SCIENCE, TECHNOLOGY AND UNIVERSITY OUTREACH, OF *North Carolina's 2002 Economic Development Strategic Plan*

Federal Funding from All Sources for R&D in North Carolina



Funding from the National Institutes of Health, 2002

State	Per Capita Amount
1 Massachusetts	\$295
2 Maryland	\$209
3 Connecticut	\$115
4 Washington	\$114
5 Rhode Island	\$110
6 Vermont	\$105
7 Pennsylvania	\$101
8 North Carolina	\$97
9 New York	\$90
10 Missouri	\$86
11 California	\$86
12 Minnesota	\$76

SOURCE: NATIONAL INSTITUTES OF HEALTH

... biotech regions are leaders because they have two necessary elements for industry growth: strong research capacity and the ability to convert research into successful commercial activity.

— Signs of Life, BROOKINGS INSTITUTION REPORT

to early stage research projects that enable North Carolina scientists, particularly the younger ones just beginning their careers, to generate the initial data they need to more successfully compete for large federal grants that fuel university innovation.

Attracting and retaining research talent

In many leading biotechnology states, economic development policies are focused on attracting top scientific talent to both their public and private universities. These scientists in turn recruit high-quality graduate students and post-doctoral fellows, and are responsible for bringing large federal grants to their institutions. However, competition today for talent in the life sciences is fierce and expensive. Start-up packages for scientific talent range from \$200,000 to more than \$3 million, not counting faculty salary.

At North Carolina’s public research institutions, average faculty salaries are lower than in many other top biotechnology states, so universities are struggling to attract and retain world-class faculty.

This is difficult enough at the state’s major universities, but is an even greater challenge for the regional institutions. These institutions historically have had limited resources and name recognition. Lack of sufficient funding makes it very unlikely that they can attract leading scientists. If high-quality biotechnology research is to be a statewide endeavor, North Carolina must respond accordingly.

Students are as important as their professors.

Funding constraints also hinder the ability of departments to attract top graduate students. Gifted students support research because they not only do much of the laboratory work to move projects forward; they also produce more and more creative ideas themselves as they mature. Once in North Carolina, graduate students tend to stay or return later in their career because of the quality of life available here. They are the future employees of innovative businesses. Graduate students are much less expensive to recruit than their professors, so investing in them is a cost-effective way to build an essential part of North Carolina’s research workforce.

A necessary tool in recruiting graduate students is tuition remittances. Currently, the state funds a number of tuition remittances. This is a successful program, but it has limitations.

- Allocation of tuition remittances within the university system favors the largest research institutions, UNC-Chapel Hill and N.C. State.
- Even at the state’s largest research institutions, only a portion of the state’s life sciences graduate students are covered.

If the goal is to grow research at regional research institutions around the state and increase diversity in the workforce, North Carolina needs a tuition remittance allocation that enhances graduate programs at all institutions.

Building statewide biotechnology research infrastructure

In addition to scientific talent, university research depends on a strong infrastructure of scientific equipment, specialized research centers, powerful computing resources and general operating support. The state has previously provided this kind of support for life sciences research, but current funding constraints are weakening that infrastructure.

A key source of funding for biotechnology research equipment has been the Biotechnology Center's Institutional Development Grants Program. This competitive grants program funds major multi-user equipment centers, encouraging collaborative research and leveraging matching funds from other sources. But funding for this program has decreased by more than 50 percent in the last two budget cycles.

If all North Carolina regions are to share in future opportunities for biotechnology-related economic development, the state and its partners must also invest in development of regional research centers to support biotechnology-related competitiveness assets that are distinctive to each sector. Examples might be marine sciences in the east, and forest, natural products and environmental biotechnology in the west.

North Carolina's information technology infrastructure is also currently strained by the demands of biotechnology research. Moreover, the new fields of genomics and bioinformatics that are the foundation of the medical discoveries of the future are highly computer-intensive.

Supporting innovative research

Federal funding agencies generally reward a low-risk approach to research that builds on past success. Projects that explore "thinking outside the box" aren't as likely to be funded. Although the NIH is trying to address this, critics have maintained that the agency traditionally funds scientifically conservative research that produces incremental results, while failing to support cutting-edge, high-risk research that may fail or may catapult science into new realms.

Seed funding bears fruit for vaccine researcher, company

In biotechnology small amounts of money provided to the right projects at the right time can reap big rewards down the line. Just ask Dr. Robert Johnston, director of the Carolina Vaccine Institute at the University of North Carolina at Chapel Hill.

Johnston received a \$24,000 Academic Research Initiation Grant (ARIG) from the North Carolina Biotechnology Center in 1987 to develop a genetically engineered vaccine for the Venezuelan equine encephalitis (VEE) virus.

"The grant was crucial in helping us begin studies on the VEE system, which ultimately resulted in the formation of AlphaVax, Inc.," Johnston recalled.

AlphaVax, based in Research Triangle Park, is a 43-employee vaccine company founded in 1998 by Johnston and others. The company received a \$250,000 loan from the Biotechnology Center for its early vaccine research in 1998.

AlphaVax is developing new vaccine technology based on years of research by UNC and the U.S. Army Medical Research Institute for Infectious Diseases. The technology promises to improve existing vaccines and to create new ones against a wide array of infectious diseases and cancer.

"We have always felt a tremendous debt of gratitude to the ARIG program and the North Carolina Biotechnology Center for support of our research, especially as it came at a particularly critical time," Johnston said. "Converting a good idea into a vibrant and commercially viable technology is a very difficult process throughout, but good ideas don't even get a chance without the initial seed money to demonstrate their potential. That is what the Biotechnology Center's ARIG funding provided to us."

AlphaVax has received about \$39 million in federal grants during the last two years to develop vaccines against HIV and two groups of disease-causing agents that could be used in terrorist attacks: botulinum neurotoxins and equine encephalomyelitis viruses.

"In addition, our laboratory at UNC is operating on approximately \$18 million of current and committed grant monies, all based on projects descending directly from the work funded in the beginning by the Biotechnology Center grant," Johnston said. "It's safe to say that these accomplishments certainly would have been delayed significantly without the Biotechnology Center funding, and it is reasonable to surmise that they may never have occurred at all without that support."

Most scientists will not pursue research based on new, unproven ideas if they do not have the grants to do so. Without grant funding, scientists are in danger of losing access to university resources and, ultimately, their livelihood. In the past, the State met this need for high-risk life science research through

Company's patience gives patients new drug against AIDS

In their labs at Duke University Medical Center, Dr. Dani Bolognesi and Dr. Tom Matthews spent years studying HIV, the virus that causes AIDS. In the early 1990s they discovered a molecule that inhibited the virus from infecting healthy cells.

Today that molecule is known as Fuzeon, the first in a new class of powerful drugs to treat AIDS.

The path from idea to marketed drug was long, expensive and difficult. It began in 1993 when the two Duke scientists formed a Durham company, Trimeris Inc., to develop their discovery.

A \$250,000 loan from the Biotechnology Center helped Trimeris conduct research and raise venture capital. A patent for Fuzeon was granted. Lab and animal testing began, followed by early human clinical trials. The company raised \$33 million in a public stock offering and hired more employees. It formed a collaboration with F. Hoffmann-La Roche to develop, manufacture and commercialize the drug on a global scale. Advanced clinical trials were conducted, and a New Drug Application was filed with the FDA.

Finally, after more than 10 years of work and tens of millions of dollars invested, Fuzeon gained FDA approval and was commercially launched in 2003. Today Fuzeon is making a huge difference in the lives of thousands of AIDS patients, and Trimeris is making a big contribution to North Carolina's economy with 135 employees on the payroll.

the Biotechnology Center's Academic Research Initiation Grant (ARIG) Program, but the program has been discontinued due to budget cutbacks. This proven program helped North Carolina universities attract on average about \$14 in federal research for each state dollar granted and generated innovative research that led directly to the establishment of new companies such as AlphaVax. Building on a \$24,000 ARIG to a key investigator and a subsequent \$250,000 loan from the Biotechnology Center, AlphaVax has received \$39 million in federal grants.

Generate New Ideas: Recommended Strategies

Attract and retain research talent		
1	<i>Re-commit to funding the existing endowed chairs for faculty and establish a general fund for faculty start-up packages.</i>	Currently, more than two-dozen endowed chairs in biotechnology-related areas remain un-funded by the General Assembly. Not only are universities deprived of the faculty to fill these chairs, but this lack of funding commitment also deprives North Carolina of an opportunity to leverage \$2 in corporate, alumni and charitable foundation contributions for every \$1 invested by the state. The state should renew its commitment to the endowed chairs, fund the endowed chair backlog, and establish a general fund for faculty start-up packages.
2	<i>Recruit targeted faculty through the Biotechnology Center's Faculty Recruitment Grant Program.</i>	The State has previously funded targeted faculty recruitments through the Biotechnology Center's Faculty Recruitment Grant Program. During the last 17 years, this program has invested more than \$9.8 million to attract 46 highly respected faculty members to public and private universities in North Carolina. In turn, those scientists have attracted more than \$160 million in research funding. Unfortunately, this recruitment program is operating at about one-tenth its former level due to State funding cuts. Additional funds are required to broaden the program's ability to help North Carolina universities remain competitive.
3	<i>Recruit top graduate students.</i>	Attracting top graduate students pays enormous dividends. The most cost-effective way to build the high end of North Carolina's biotech workforce is to recruit scientifically gifted students in their formative years and to retain them.
Build statewide biotechnology research infrastructure		
4	<i>Renew and expand State funding for equipment and instrumentation through Biotechnology Center programs.</i>	Scientists must have up-to-date tools to compete in the ever-changing world of biotechnology research. The State should provide increased resources to Biotechnology Center programs that support the purchase of major multi-user equipment and instrumentation at research universities throughout the state.
5	<i>Develop a statewide network of research centers focused on key regional resources.</i>	Cutting-edge research often comes from specialized centers that bring together scientists to focus on a specific scientific frontier. These centers can be important components of a region's economic strategy. The State should consider funding a few new research centers that would be located in regions around the state, would focus on a resource unique to that region (e.g., natural products from the Appalachian mountains in western North Carolina), and would facilitate each region's economic development.
6	<i>Seek federal funds to create a powerful statewide information technology infrastructure to support biotechnology research.</i>	With the guidance of the North Carolina Genomics and Bioinformatics Consortium, the State, its universities, and industry should form a partnership to obtain federal funding to develop a dynamic, statewide, distributed-computing approach to data management and sharing for biotechnology.
Support innovative research		
7	<i>Support early-stage applied research through Biotechnology Center Academic Research Initiation Grants.</i>	New company creation results directly from innovative, high-risk research. However, most federal funding agencies generally reward a conservative, low-risk approach to research that is less likely to yield commercially relevant discoveries and company creation. The State should increase the Biotechnology Center's appropriation so that it can restore funding for the Academic Research Initiation Grants program and other grants programs that support high-risk projects and multidisciplinary collaboration.

Move Ideas to Market

Creating new ideas is only the beginning of the university's role in biotechnology economic development. The university is also the gateway from the mind to the market. New knowledge is essential for a dynamic, growing and prosperous biotechnology industry. It produces the intellectual property that generates the commercially viable products, processes and services to support the formation, growth and profitability of biotechnology companies. Because the industry is both science-based and young, it depends on a constant flow of discoveries from university and private labs. The ways in which universities interact with companies are at the heart of the biotechnology economy.

More than a third of North Carolina's biotechnology companies began in a university.

Transforming new ideas into commercial opportunity

The movement of ideas from the laboratory to commercialization is known as technology transfer. Technology transfer happens at the intersection where university and industry meet. Most universities across North Carolina have commitments to economic development through their technology transfer activities. Eight North Carolina universities have formal technology transfer offices, and others that don't have dedicated offices are nonetheless active in technology transfer.

North Carolina's technology transfer offices have succeeded in working with faculties to make certain scientists aware of intellectual property that might have commercial applications and should be patented. But technology transfer extends beyond patent applications. It also includes licensing and creating university start-up companies.

How these technology transfer functions are handled by a university directly affects how much a state will benefit from university creation of new ideas. The figure *University Technology Transfer* on page 40 shows the broad outlines of the role that technology transfer plays in economic development.

Because North Carolina universities are committed to economic development, they attempt to consider economic gains to the state in the creation of their technology transfer strategies. Different universities naturally have different faculty, different research specializations, and different approaches to technology transfer. However, all their strategies are affected by the resource constraints in the current university environment as well as the larger financial environment in which they operate.

Technology transfer activities include a delicate balance of licensing new technology to existing companies versus creating a university start-up company, and licensing the technology to the start-up company. When possible and

The value of university technology licensing

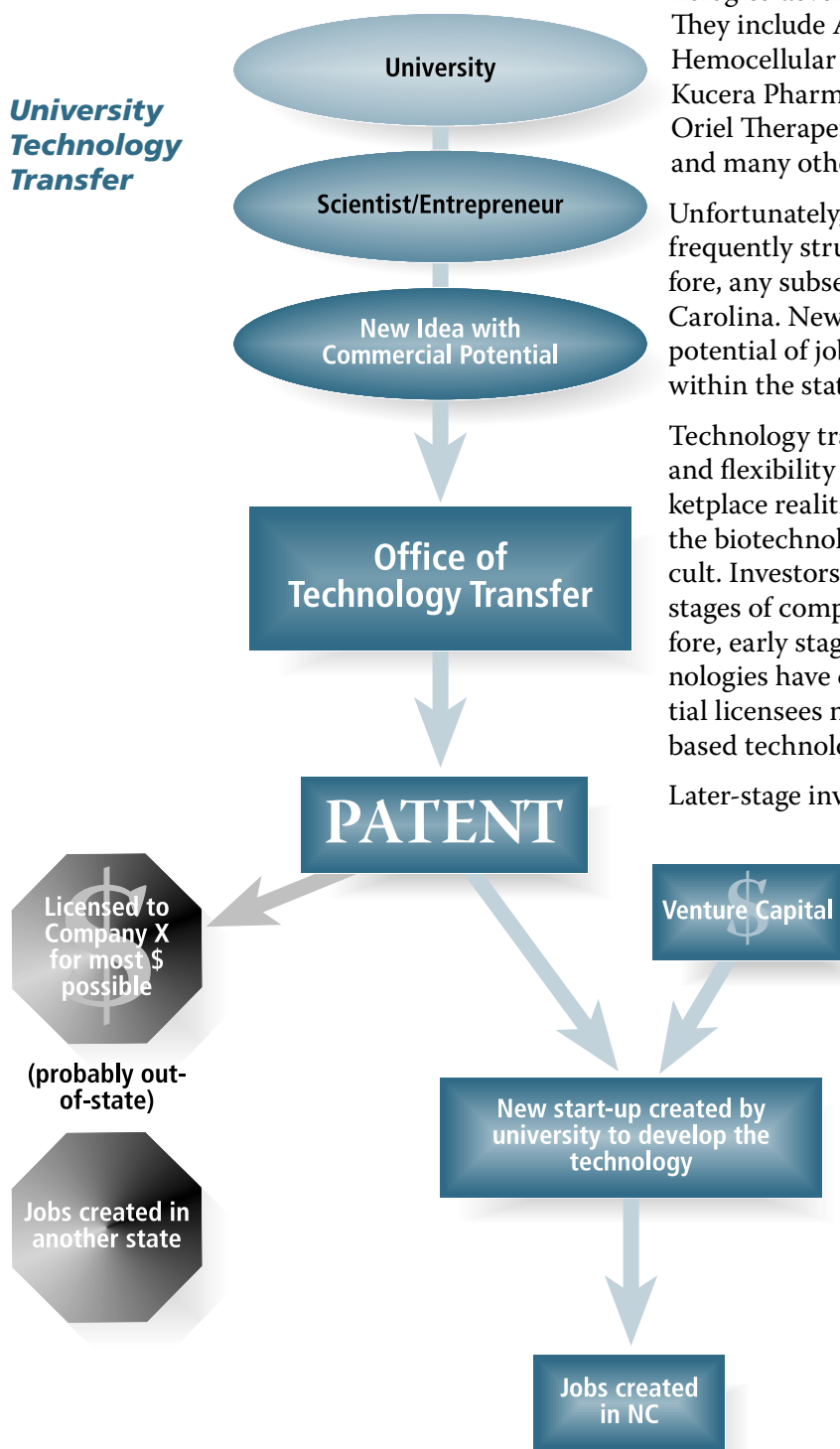
As reported on the Biotechnology Industry Organization's Web site:

"The Association of University Technology Managers (AUTM) publishes detailed data on the economic impact of licenses of universities, hospitals, and nonprofit organizations engaged in the process of transferring inventions from academic and related research organizations. These licenses are the critical means for ensuring that basic research is developed into products for the benefit of consumers.

An economic model developed by AUTM shows that in FY 1997, \$28.7 billion of U.S. economic activity can be attributed to the results of academic licensing, supporting 245,930 jobs. In FY 1996 and 1995 the comparable figures were \$24.8 billion and 212,500 jobs and \$21 billion and 180,000 jobs respectively.

...it is clear that an overwhelming percentage of all of the economic activity reported in those surveys comes from life sciences research and technology transfer. "

University Technology Transfer



appropriate, many universities pursue start-up company creation, which keeps the economic potential of new technology within North Carolina. More than a third of the state's biotechnology companies were started based on tech-

nologies developed by North Carolina universities. They include AlphaVax, Biolex, EcoGenomix, Embrex, Hemocellular Development, Inspire Pharmaceuticals, Kucera Pharmaceutical, LipoScience, Merix Bioscience, Oriel Therapeutics, Sphinx Pharmaceuticals, Trimeris and many others.

Unfortunately, the most lucrative licensing deals are frequently struck with out-of-state companies; therefore, any subsequent job creation is beyond North Carolina. New company creation, however, has the potential of job growth and taxable revenue generation within the state.

Technology transfer offices must have the resources and flexibility to be as responsive as possible to marketplace realities. Today's risk-capital environment for the biotechnology and life sciences industries is difficult. Investors and licensees tend to participate at later stages of company and technology development. Therefore, early stage investments in university-based technologies have decreased. Current investors and potential licensees need more fully developed university-based technologies.

Later-stage investment affects how many resources a university can devote to developing a technology before it is ready for licensing to an established company. It also affects when a university start-up company based on the new technology can attract investment. The bottom line is that university technology transfer offices today need more resources to develop technology to a later stage than they did previously. For some universities, these resources may mean internal resources for technology development. For other universities, it may be better to have an entity outside of the university that is dedicated to very early stage investment in technology development. In addition, for technologies better suited for licensing, the process of negotiating the license should be as quick and easy as possible.

Making the university-industry connection

The role of the university in economic development extends beyond technology transfer. Connections between universities and industry, though subtle and broad, are vital because they promote economic development.

Many universities are already establishing close and appropriate collaborations with industry through innovative models such as the Millennium Campus Act. The Act supports the adoption of North Carolina State University's Centennial Campus model by other universities across the state. Many universities, including UNC-Chapel Hill, UNC-Charlotte, UNC-Greensboro, N.C. A&T and Western Carolina University, are working on Millennium Campus projects.

Businesses and economic developers also benefit from establishing close and productive relationships with universities in their communities. In fact, the benefits of communication flow in both directions. University research expertise helps businesses and is therefore a business-recruitment asset, while business leaders provide essential advice to universities on strategic directions and ways to commercialize new ideas.

It is also helpful for universities and industries to communicate about skill sets needed by graduates. Universities can in turn use this information to help design courses and to make more informed faculty-hiring decisions. Industries in turn are able to get the expertise they need locally rather than having to search nationally or internationally. It is important to remember that one reason why the Research Triangle Park was created was to reduce the "brain drain" of faculty and students from the state.

Supporting the scientist-entrepreneur

In today's economy, productive interaction between academia and industry is both a requirement and a challenge. Universities and the private sector function in very different realms with different objectives, values, incentives and cultures.

University-industry culture clashes can occur. However, with the vision and encouragement of the state's leaders, and the commitment of the UNC System to the economic development mission of the universities, North Carolina's universities have had early success in the state's innovation economy. They take their role in economic development seriously.

Technology transfer: one scenario

Universities need the flexibility to meet their specific technology-transfer needs in response to marketplace realities. There are many different possibilities for viable models of technology transfer. Consider the following example:

At Future University, technology transfer activities are handled through a new organization with innovative functions, diverse funding sources and the flexibility required to maximize the impact of university discoveries on job creation in North Carolina. What is that organization and how does it work?

Innovation Corporation (IC) is a private organization, for-profit or non-profit, and external to, but affiliated with, Future University. IC has a corporate board and a CEO who reports jointly to the board and to the Chancellor or his/her designee and is accountable for performance goals. Performance benchmarks are tightly aligned with operating objectives, budgets and other resource allocations.

Functions of IC:

- IC has personnel for a range of activities: 1) aggressive business developers comfortable carrying out a full range of start-up business planning activities and promoting the needs of early stage companies; 2) experienced deal makers negotiating for the best licensing deals possible; 3) outreach personnel who are dedicated to cultivating positive relationships with faculty and keeping track of their inventions; and 4) staff who specialize in other aspects of technology licensing and development.
- As a private organization, IC has flexibility in salary schedules and performance-based compensation sufficient to attract and retain extremely talented technology-development professionals.
- IC has access to a variety of funds and incubation space to support its early stage companies until they are mature enough to attract sufficient venture capital and move forward more independently. These funds come partially from the university's endowment, and also from other sources including private investors. Angel investors are cultivated from successful alumni, who are also encouraged to help mentor the CEOs of the start-up companies in which they are investing.
- University faculty (from the Business School and elsewhere), alumni and friends serve as advisors to the start-up companies on finance, marketing, operations, and other topics as needed.

However, because the UNC System is not formally charged with economic development, the scope of university involvement in economic development may not be clear to all parties, both inside and outside the university. The current mission statement charges the universities to “discover, create, trans-

Companies spring from university technologies

More than 50 biotechnology companies throughout the state are based on technologies developed at North Carolina universities, including the following examples.

Company	University
AlphaVax	UNC-Chapel Hill / N.C. State
Biolex	N.C. State
BioMarck Pharmaceuticals	N.C. State
BioResource International	N.C. State
DarPharma	UNC-Chapel Hill
EcoGenomix	UNC-Greensboro
Embrex	N.C. State
Hemocellular Development	East Carolina University / UNC-Chapel Hill
Inspire Pharmaceuticals	UNC-Chapel Hill
Kucera Pharmaceutical	Wake Forest University / UNC-Chapel Hill
LipoScience	N.C. State
Merix Bioscience	Duke
Norak Biosciences	Duke
Oriel Therapeutics	UNC-Chapel Hill
Qualyst	UNC-Chapel Hill
Sphinx Pharmaceuticals (acquired by Eli Lilly)	Duke
StemCo	Duke
Trimeris	Duke

mit, and apply knowledge to address the needs of individuals and society” through instruction, research, scholarship, creative activities and public service. Economic development is not explicitly addressed in the mission statement or in the UNC strategic directions. Clarifying the economic-development role of the universities in the strategic directions could help build on the solid commitment that the universities have already made.

Along with the formalization of the university commitment to economic development should come resources for the universities to pursue this mission and adjust their internal incentives. In the biotechnology-related scientific fields, faculty researchers are often constrained in their ability to engage in industrial and economic development activities such as industry-sponsored research, applied research, entrepreneurial business creation and technology transfer. They are pressured to meet traditional standards of career progress that focus mainly on the number of publications in prestigious academic journals. Publications are, and will remain, central to establishing and maintaining scientific credibility, but today the number of publications in basic research journals is not necessarily the most accurate indication of a faculty member’s worthiness or impact on the field. Considering the total impact of all faculty achievements in promotion and tenure decisions could help reward faculty for participating in economic development activities.

Some faculty members find that, after they make a commercially important discovery, moving that technology into the marketplace requires substantial amounts of their time. Having university policies that encourage an “entrepreneurship sabbatical” could help give faculty the time to develop technologies sufficiently for commercialization.

Faculty who have conducted commercially significant research that results in a start-up company sometimes find that they could benefit from specialized guidance in company formation and product development. This is particularly important in the current economic climate because most venture investors are waiting until late in the development cycle before investing. These faculty could benefit from a dedicated university “entrepreneur-in-residence” who could act as the interim CEO of a new company and network with potential angel investors, venture capitalists and other funding sources.

Move Ideas to Market: Recommended Strategies

Transform new ideas into commercial opportunity.		
8	<i>Provide universities with the resources and flexibility to structure technology transfer offices that meet their unique needs.</i>	North Carolina has good momentum in technology transfer. To accelerate the growth of the state's biotechnology-related industries, technology transfer offices must have the resources to execute strategies that are in the best economic development interests of the state. And they need the flexibility to modify their methods of technology transfer to best meet the changing realities of the marketplace.
Make the university-industry connection.		
9	<i>Utilize existing and new research parks to facilitate regional biotechnology development.</i>	Research parks, university-based or independent, provide functioning sites for biotechnology training, university-company partnerships, university-based spinouts, and shared facilities. Goals and development of the new Millennium Campuses statewide can include biotechnology activities appropriate to the resources of the universities and communities they serve.
10	<i>Establish university leadership/economic development networks.</i>	Universities across North Carolina should work consistently with the Department of Commerce and local economic developers to enhance business recruitment and retention. The state's Small Business and Technology Development Center offices would be an asset to this endeavor, as would Biotechnology Center satellite offices.
11	<i>Strengthen ties between universities and industry.</i>	The challenge for both universities and businesses is to find common ground between their very different cultures and ways of operating. Universities must balance their open and objective pursuit of basic knowledge with their pursuit of research for commercial gain. Having a single point of contact within the university responsible for coordinating and facilitating industry relations could encourage university-industry connections.
Support the scientist-entrepreneur.		
12	<i>Define the economic development missions of the universities.</i>	The UNC Board of Governors should update the UNC System strategic directions to acknowledge and formally accept the key role the universities play in economic development. The new strategic directions should focus on university contributions such as start-up companies, impact of graduates employed in the regions, new companies, and technology transfer, all of which can help improve the economies of the regions served by the universities through creation of jobs, wealth and opportunity. However, this expansion of the economic development role must be carefully considered and structured so that it complements and contributes to the traditional university roles of education, public service and research.
13	<i>Incorporate an evaluation of "total impact" into faculty promotion and tenure decisions.</i>	Individual faculty should be able to build successful careers in academia while placing greater emphasis on applied research, intellectual property creation, entrepreneurial ventures, teaching, and mentoring graduate students.
14	<i>Provide support to faculty for pursuing entrepreneurial endeavors and entrepreneurial sabbaticals.</i>	Promising faculty members working toward commercially relevant discoveries should be encouraged and allowed to apply for sabbaticals to pursue entrepreneurial activities. These entrepreneurial sabbaticals would be distinct from research sabbaticals, and should have a separate funding source. The funding could come from either the universities' technology transfer functions or a centralized fund established at the Biotechnology Center, to ensure eligibility for faculty at both public and private universities and not-for-profit research institutes. Sabbatical awards should be made on the basis of importance and commercial potential of the faculty applicant's research.

Move Ideas to Market: Recommended Strategies

15	<i>Establish an entrepreneurs-in-residence program.</i>	Entrepreneurs in residence would provide the unique skills needed to interact closely with the scientist-entrepreneur during the early stage of company formation. The entrepreneur-in-residence could act as interim CEO of multiple early stage start-up companies, and grow the companies to the stage where a full-time management team would be needed. The entrepreneur-in-residence could be based in either the university technology transfer office or the business school. Once a critical mass of entrepreneurs-in-residence exists around the state, the Council for Entrepreneurial Development, working with the Biotechnology Center, could convene statewide quarterly meetings of them to share ideas, experiences, and resources.
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Start and Grow Companies

North Carolina is home to dozens of entrepreneurial biotechnology companies that began either as spinouts from larger life sciences companies or as new companies based on discoveries licensed from a private or public research university in the state. Once concentrated almost exclusively in the Research Triangle area, new biotechnology companies are beginning to emerge in other parts of the state, including the Triad, Western North Carolina, Charlotte and the East.

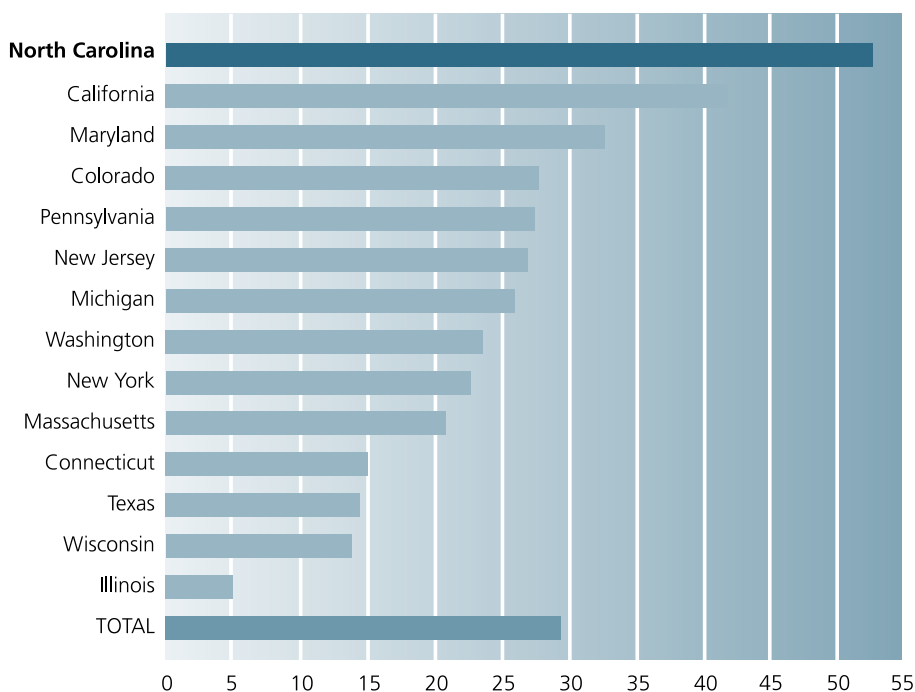
It should not be surprising that North Carolina led the nation in creating new biotechnology companies during the most recent five years measured by a 2003 U.S. Department of Commerce study. As discussed in the prior two chapters, the state is home to many outstanding public and private research universities that provide a steady supply of new ideas and intellectual property with commercial potential in biotechnology. In addition, the state's larger life sciences companies routinely out-license technologies and discoveries that will not be developed further in-house.

Those out-licensed technologies often form the basis of new companies in North Carolina.

Helping these young companies grow and facilitating the creation and growth of additional biotechnology companies should be a high priority for North Carolina. While larger companies, particularly those engaged in biomanufacturing, can bring many jobs quickly, the State cannot rely solely on recruiting big companies to meet its long-term economic development needs. The tremendous competition for the relatively small number of these opportunities makes that approach too risky. A balanced job-creation strategy that includes building new biotechnology companies, as well as attracting both established and emerging companies to the state, offers much greater potential over the long term.

That is not to say that biotechnology start-ups are risk-free. In fact, biotechnology companies are relatively high-risk ventures, and some fail. The risk of failure, however, is balanced by the opportunity for great rewards. These companies are potentially high-growth, wealth-producing businesses that create good jobs.

Percentage Growth in New Biotechnology Company Establishments by State, 1997–2001



SOURCE: "A SURVEY OF THE USE OF BIOTECHNOLOGY IN THE U.S. INDUSTRY, OCT. 2003" U.S. DEPARTMENT OF COMMERCE – TECHNOLOGY ADMINISTRATION

Biotechnology companies that are successful and provide good returns to their early investors help attract more investment capital to their communities, which in turn supports the creation of more start-up companies and more jobs. Mature biotechnology companies yield seasoned entrepreneurs who transition back into new start-ups, thereby increasing the likelihood of success for these new ventures. Some biotechnology companies grow into major corporations that spin off new ventures and build alliances with, or invest in, new biotechnology start-up companies. This activity is a positive loop that yields continuous economic growth. North Carolina can encourage this loop by supporting the promising companies that are on track to become major corporations.

Of chickens and eggs: Embrex transforms the poultry business

In the old days of the poultry business, newborn chicks were vaccinated by hand, a cumbersome and expensive method that was also stressful to the birds.

Today many poultry hatcheries around the world use an automated egg-injection system to vaccinate poultry *in ovo*, or in the egg. The system, developed by Embrex Inc. of Durham, saves time and money and gets the chicks off to a healthier start. It is used to vaccinate more than 80 percent of broiler birds raised in North America against Marek's disease.

The Inovoject® system is one of several patented biological and mechanical products developed by Embrex that improve bird health, reduce bird and production costs and provide other economic benefits to the worldwide poultry industry. The company's product portfolio also includes Bursaplex®, a USDA-approved vaccine against infectious bursal disease.

Founded in 1985, Embrex received \$221,192 in early financial assistance from the North Carolina Biotechnology Center for its research and development. The company went on to raise \$16 million in venture capital and gain \$27.5 million in two public stock offerings. Today it is a profitable company that employs 140 North Carolinians — many of them engineering and poultry science graduates of North Carolina State University. Embrex is building a new vaccine-production plant in Laurinburg that will employ 35 additional workers.

Helping emerging companies succeed

If the environment is supportive, biotechnology companies tend to cluster near the source of their technology and remain there as they grow. Unlike most other states — even those with more biotechnology companies and workers — North Carolina has a well-developed biotechnology community that is committed to maintaining a positive environment for entrepreneurial biotechnology companies. This community has been nurtured and facilitated by organizations such as the Biotechnology Center, the Council for Entrepreneurial Development, the North Carolina Biosciences Organization (NCBIO, the trade association for North Carolina's biotechnology industry), the Small Business and Technology Development Center, and the community colleges' Small Business Center Network. These non-profit organizations routinely work together on initiatives designed to help young companies succeed. The state's community colleges, public and private universities, venture capitalists, economic developers, and government agencies are also active participants in North Carolina's biotechnology community.

Unfortunately, a supportive environment alone is not enough to guarantee the success of emerging biotechnology companies. Successful biotechnology companies also require intellectual property (discussed in two prior sections), large amounts of research funding and investment capital, and seasoned entrepreneurial leaders knowledgeable in science and business.

To give its young biotechnology companies the greatest possible chance to grow and succeed, and to help attract companies to the state, North Carolina needs to ensure that its business policies support the risk/reward trade-offs inherent in these companies. By increasing State funds available for investment in North Carolina biotechnology start-up companies, aggressively marketing investment opportunities in North Carolina biotechnology companies to national and international investors, and enacting tax policies that encour-

age biotechnology company formation and growth, the State would stimulate substantial economic development.

State actions to address the challenges faced by emerging biotechnology companies should be augmented by additional initiatives undertaken by the private sector and North Carolina's broader biotechnology community. In particular, these organizations could help cultivate and develop biotechnology entrepreneurs and could create new programs to help biotechnology companies access funding, scientists, technologies and other forms of research assistance from federal agencies. Apart from grant programs designed to support research by small businesses (SBIR/STTR), most North Carolina companies are barely aware of the vast resources available from the National Institutes of Health and other federal agencies to support their innovative research.

Increasing sources of early stage investment capital

The investment required to develop a new biotechnology product, particularly one for human health care, ranges from tens of millions to hundreds of millions of dollars. By the time it receives approval from the FDA, a new human therapeutic may require investment upwards of \$500 million. Capital is also needed over a long period of time — in some cases even a decade or more — because of the extensive research, development and testing that is required to commercialize a product in a regulated market.

At the earliest stage, when a biotechnology company is developing its new ideas, capital comes primarily from individual investors called “angels” and from federal and other research funding sources. If an idea looks promising as a commercial product, the company requires more funds to develop a prototype and to bring the product to market. Capital for these later stages comes from venture capital funds and strategic partnerships with large companies.

As companies mature and their products become commercially viable, many turn to the equity market for financing, often raising tens or hundreds of millions of dollars in initial public offerings and subsequent follow-on offerings of stock. In the last three years, however, there have been very few initial public offerings by biotechnology companies — and none in North Carolina — due to the depressed economy and bearish stock market. This has given venture capitalists fewer opportunities to “cash out” their investments, and thereby constricted the flow of new venture capital investments. Biotechnology companies hungry for cash, especially the higher-risk early stage companies, have suffered from the capital shortage.

Targacept navigates long, winding road to new drugs

With about \$90 million raised in venture capital since August 2000, Targacept could be labeled an overnight success. But the Winston-Salem company's rise to prominence has actually been a 15-year journey.

Targacept, which operates in the Piedmont Triad Research Park, grew out of research by its parent company, R.J. Reynolds Tobacco, in the pharmacology, chemistry and toxicity of nicotine. The company spent nearly 10 years in incubation from the late 1980s until it was formally established in 1997.



DAVID SMALL PHOTOGRAPHY

Targacept's headquarters in the Piedmont Triad Research Park

The company spun out from R.J. Reynolds in 2000 and raised \$30.4 million, the fourth largest figure in North Carolina at that time.

Targacept is working on medications that focus on the central nervous system and specifically, nicotinic receptors. It is developing compounds

that can stimulate the receptors to ease the symptoms of such diseases as Parkinson's and Alzheimer's. The company's other lead compound is geared toward ulcerative colitis.

Investors have been impressed with Targacept's compounds and 66-member work force. The company secured \$46 million in new venture capital investments in late 2002.

The Brookings Institution's *Signs of Life* report indicates that while the Research Triangle is among the top five metropolitan areas with the highest concentrations of venture capital for life sciences, it still lags far behind California and Massachusetts, homes to the largest concentrations of biotechnology companies

Award-winning entrepreneur thrives in North Carolina

Is North Carolina a good place for a biotechnology entrepreneur to grow a company?

"Absolutely," says Christy Shaffer, chief executive officer of Inspire Pharmaceuticals, a drug-development company in Durham. "North Carolina is a nurturing place with organizations like the Council for Entrepreneurial Development and the North Carolina Biotechnology Center. The atmosphere in North Carolina is such that people tend to help one another... We know each other well and can call on each other when times are tough."



Christy Shaffer, Ph.D., chief executive officer, and Greg Mossinghoff, president, are pictured with Bruce Aust (right), NASDAQ's executive vice president.

Shaffer knows firsthand the challenges and rewards of leading a young biotechnology company. Her fast-track career has taken her

from a university research lab to the executive suite of a publicly traded company on the verge of its first product approval.

Shaffer, who has a Ph.D. in pharmacology from the University of Tennessee, came to North Carolina in 1987 for a neurobiology fellowship at the University of North Carolina at Chapel Hill with one of the founding scientists of Inspire Pharmaceuticals. She then left academia to work in clinical research at Burroughs Wellcome before its merger with Glaxo. In 1995 she became the first full-time employee of Inspire and within four years was appointed CEO.

Under her leadership, Inspire raised \$78 million in an initial public offering of stock in 2000, gained another \$78 million in a secondary offering in 2003, and filed a New Drug Application with the FDA for its first product, an ophthalmic drug for dry eye disease. The company hopes to receive FDA approval for its first product in 2004.

in the country. There is even less available capital outside the Triangle area and notably little connection between the state's biotechnology entrepreneurs and the highly developed banking and finance industry in Charlotte.

The Economic Development Investment Fund

Historically, the Economic Development Investment Fund (EDIF) established and managed by the Biotechnology Center has provided loans to companies at very early stages of development when risk of failure is particularly high. Yet, the Biotechnology Center has had a good track record of picking winners through careful review of applicants based on their business plans, their management teams, and the scientific merit of their intellectual property. Though small, loans from the EDIF have enormous impact in helping these companies secure federal grants, form company partnerships and attract further venture capital investments. Loans totaling \$10.6 million have helped 70 young companies attract more than \$500 million in funding from other sources. However, the EDIF is being rapidly depleted. Funding must be increased if this cost-effective and successful investment strategy is to continue.

Providing direct state investment capital

Many states have recognized that risk capital must be available to early stage biotechnology companies. Wisconsin, California, Washington, Pennsylvania and New York are making state funds available to seed new biotechnology companies. North Carolina should consider making a small percentage of its escheat or pension funds available for investment by appropriately quali-

fied third-party intermediaries in early stage biotechnology companies located in North Carolina. Such an investment could help ensure that companies formed around ideas generated in North Carolina stay in the state and further add to the creation of jobs, industry, and the entrepreneurial culture.

Stimulating individual investment in biotechnology

The State's Qualified Business Venture (QBV) tax credit provides individuals with an incentive to invest in early stage biotechnology companies. Investors receive a state income tax credit of up to 25 percent of their investment

in a company in which a limited number of organizations, including the Biotechnology Center, have also invested. The QBV is set to expire in 2007. Making the QBV permanent would ensure individual investor participation in the growth of biotechnology in North Carolina for many years to come. Increasing the QBV credit cap of \$6 million and expanding the pool of investors who can claim the credit would further stimulate investments in early stage biotechnology companies and venture capital funds. In addition, providing qualifying QBV status to biotechnology company founders and board members would allow some of the individuals most critical to the success of a company to claim this credit.

Marketing North Carolina

Drawing national and global investment to North Carolina is another way to increase venture capital flow into the state's early stage biotechnology companies. Most major venture capital funds do not have offices in North Carolina and are often unaware of the substantial investment opportunities in the state. North Carolina's vibrant entrepreneurial community should be marketed to national and international investors seeking venture opportunities.

Helping companies access federal resources

Helping companies does not always require direct investment. Many small companies simply need help accessing federal resources. Federal agencies such as the National Institutes of Health can provide young biotechnology companies with scientific collaborations, research tools, technologies for licensing, and help with clinical trials of novel therapies. These interactions can also provide a stamp of credibility for biotechnology companies trying to prove their technologies and products. Increased outreach and networking activities organized and coordinated by State agencies and nonprofit organizations can help company executives learn more about federal resources.

Providing targeted tax relief

Biotechnology companies need a supportive business climate to encourage their growth. Various states offer tax policies favorable to the growth of biotechnology companies. North Carolina should examine these policies — and compare them with its own — to ensure that the State is competitive. These might include the R&D tax credit, potential sales tax exemptions and ways to encourage repeat investment in North Carolina by “serial entrepreneurs.” Several approaches to refining tax policies and stimulating investment in biotechnology and other knowledge-based companies have been proposed in the State's Economic Development Board strategic plan titled “We Are Changing the Way We Do Business,” released in 2002. These should be given careful consideration.

Venture capital drives bioscience companies

Following are some of the North Carolina-based venture capital and angel funds that have invested in bioscience start-up companies throughout the state in the last two years:

- Academy Centennial Fund
- Academy Ventures Funds
- A.M. Pappas & Associates
- Atlantis
- Aurora Venture Funds
- BD Ventures
- BioVista Capital
- Charlotte Angel Partners
- Dogwood Equity
- Eno River Capital
- Franklin Street Partners
- Frontier Capital
- Intersouth Partners
- Kitty Hawk Capital
- N.C. Enterprise Fund
- Piedmont Angel Network
- Research Triangle Ventures
- Tri-State Investment Group of Chapel Hill
- Wakefield Group

Developing successful entrepreneurs

Seasoned management teams capable of taking a biotechnology company from start-up to profitability are relatively scarce in North Carolina. The skills

Big companies, mergers provide entrepreneurial talent

Robert Ingram, former chief executive officer of GlaxoSmithKline, once noted that big mergers are an excellent way to build new companies. The record certainly bears him out.

Textbook examples came in the 1990s when Burroughs Wellcome merged with Glaxo and then Glaxo Wellcome merged with Smith-Kline Beecham. The mega-mergers prompted seasoned pharmaceutical executives to seek new opportunities and create their own companies.

"Many of the successful local companies have been or are currently led by a senior team made up of folks from (the merged companies)," said Christy Shaffer, chief executive officer of Inspire Pharmaceuticals Inc. Shaffer joined Inspire Pharmaceuticals from Burroughs Wellcome in June 1995 as the company's first full-time employee.

More than 20 bioscience companies in North Carolina have been started by former Burroughs Wellcome, Glaxo and SmithKline Beecham executives who left the big companies but remained in North Carolina.

For instance, Lineberry Research Associates of Research Triangle Park was started by Charles and Cathy Lineberry, both former Burroughs Wellcome executives. The drug development company Pozen was formed in Chapel Hill by John Plachetka, a former Glaxo executive. Triangle Pharmaceuticals (later acquired by Gilead Sciences) was founded in Durham by former Burroughs Wellcome executive David Barry. And in Wilmington aaiPharma was formed by former Burroughs Wellcome executive Frederick D. Sancilio, and PPD was founded by former Glaxo executive Fred Eshelman. These five companies collectively employ more than 3,000 North Carolinians in high-paying jobs.

required are highly specialized and vary not only with the business focus, but also with the stage of company development. In many cases, biotechnology company founders and early stage biotechnology company executives have strong scientific backgrounds but lack the business experience and skills that enable them to grow with their companies. Likewise, senior managers who come from prosperous large companies often have little experience managing smaller companies with limited resources.

North Carolina needs to develop a deeper talent pool of entrepreneurial executives, managers, and company founders with the skills and experience to grow start-ups into successful companies. One way to do this is to create mentoring opportunities for new entrepreneurs. The formation of a Biotechnology Leadership Circle would provide a pool of experienced biotechnology business leaders who could mentor new entrepreneurs with feedback, coaching and advice.

Such a networking program could also give mentored entrepreneurs and their companies better access to technical information, capital and alliance opportunities. Several studies have shown that business collaboration and executive networking lead to quicker discoveries and product commercialization.

Start and Grow Companies: Recommended Strategies

Increase sources of early stage investment capital.		
16	<i>Replenish the Biotechnology Center's Economic Development Investment Fund.</i>	The State should provide immediate funding for the Biotechnology Center's Economic Development Investment Fund (EDIF), which provides seed loans and other investments in biotechnology start-up companies. Due to State cutbacks in funding for the Biotechnology Center, the EDIF is being rapidly depleted.
17	<i>Allocate a small percentage of existing State funds, such as escheat or pension, for investment in biotechnology start-up companies located in North Carolina.</i>	The State should allow and encourage investment of small percentages of the pension or escheat funds in bioscience companies. As little as 0.1 percent of a \$50 billion fund, or \$50 million, could make an enormous impact if invested in North Carolina's life sciences business community. Such investments should be made on behalf of the State by qualified third-party intermediaries, such as experienced venture capitalists or the North Carolina Biotechnology Center.
18	<i>Modify and create a permanent Qualified Business Ventures (QBV) tax credit.</i>	Making the QBV tax credit permanent would stimulate biotechnology company investment in North Carolina. Increasing the credit cap to \$12 million from \$6 million should yield sufficient credit to motivate individual investors as the economy improves. Additionally, giving the QBV tax credit to investors closest to the company would encourage them to invest more funds in the development of a biotechnology start-up company.
19	<i>Market North Carolina to national and international venture capitalists.</i>	Venture capital companies throughout the nation and world have money to invest in promising companies, but they may not be aware of good investment opportunities in North Carolina. The Council for Entrepreneurial Development, working with the North Carolina Biosciences Organization and the Biotechnology Center, should develop an effective marketing campaign to inform venture capital firms worldwide about North Carolina's investment opportunities.
20	<i>Help companies understand and access federal resources.</i>	The Biotechnology Center and the Small Business and Technology Development Center should work together to inform companies about how to access federal funding and other resources to support their research and how to establish scientific collaborations with federal agencies such as NIH.
Provide targeted tax relief.		
21	<i>Identify and implement tax policies that support biotechnology company creation and growth.</i>	State leaders should work with the North Carolina Biosciences Organization to identify and evaluate all State tax policies that could be implemented to facilitate industry development including, but not limited to, new approaches to the R&D tax credit, potential sales tax exemptions, and ways to encourage repeat investment in North Carolina by successful entrepreneurs. Consideration should be given to what other states are doing to create, attract and retain bioscience companies. This evaluation should be completed quickly, and the State should move with all haste to ensure that North Carolina's tax policies are as fair and attractive as possible to its growing life sciences industry.

Start and Grow Companies: Recommended Strategies

<i>Develop successful entrepreneurs.</i>		
22	<i>Create a Biotech Leadership Circle to mentor entrepreneurs.</i>	The Biotech Leadership Circle would enable experienced and successful biotechnology and life sciences business leaders to mentor novice executives. The mentors would provide feedback, coaching and advice, and would help connect people, opportunities and resources. The Biotech Leadership Circle should be a joint project of the Council for Entrepreneurial Development, the Biotechnology Center and the North Carolina Biosciences Organization. Once a model was established in the Research Triangle area, it could be replicated in other regions of the state. The Small Business and Technology Development Center network and Biotechnology Center satellite offices could facilitate this process.
23	<i>Provide leadership training for early stage company managers and founders.</i>	The Council for Entrepreneurial Development, working with the North Carolina Biosciences Organization and the Biotechnology Center, as well as business schools throughout North Carolina, should develop and offer a series of seminars intended for executives of start-up companies.

STRENGTHEN BIOTECHNOLOGY STATEWIDE



Recruit and Grow Companies

Attracting life sciences companies such as Glaxo, Biogen Idec, Eisai, and Wyeth to North Carolina and helping them grow has had a major positive impact on the state's biotechnology industry over the last two decades and should remain an important part of the State's strategy for biotechnology job creation. In addition to creating thousands of new jobs, these companies have been an important source of managerial talent and intellectual property for new biotechnology companies.

While investments in research and company creation are fundamental to long-term, sustainable job growth in biotechnology, proactive recruitment of small, entrepreneurial companies as well as larger, more established firms is the most immediate path to employment for many North Carolinians. This is particularly true for biomanufacturing companies, which represent an immediate opportunity for job creation. Biomanufacturing companies can grow to employ hundreds of technical workers, can be located at sites beyond academic centers, and may be the best biotechnology-related opportunity to re-employ North Carolinians displaced from traditional manufacturing jobs.

Leveraging North Carolina's assets

North Carolina is a logical location for an emerging, research-based biotechnology company or a mature pharmaceutical or chemical company seeking additional manufacturing capacity. With its impressive array of assets to attract life science businesses, both in manufacturing and R&D, the state is on most companies' short list as they consider where to grow their business.

Unfortunately, in recent years, North Carolina has not fully leveraged its advantages. Once an envied leader in company attraction, North Carolina did not win any of the top eight life sciences investments of 2002 and attracted only one of the 20 largest new or expanded R&D facility investments in the industry. Competition for this business is stiff. Biotechnology has become the mantra for many states and regions looking to improve their sagging economies.

Some of these competitors tout financial incentives and little else, hoping to "buy" companies desperate for funding, yet offering little supportive infrastructure. But other competitors are better informed about the needs of research-driven companies and use North Carolina's formula for success. They suspend regional rivalries

North Carolina has strong assets for attracting companies

- **A large concentration of life sciences companies**, with a growing number located outside the technology-rich Triangle
- **World-class public and private research universities**, with more than 4,000 faculty and technicians conducting life sciences research throughout the state
- **A community college system second to none**, with outstanding workforce training programs that are customized for individual companies
- **Supportive infrastructure**, including the Biotechnology Center and its subsidiary, the North Carolina Genomics and Bioinformatics Consortium, MCNC, NCBCIO, the Council for Entrepreneurial Development, the North Carolina Electronics and Information Technologies Association, the Small Business and Technology Development Center, and the future Biomanufacturing and Pharmaceutical Training Consortium
- **The world's highest concentration of contract research organizations** (CROs) and laboratory testing companies
- **A business climate rated Number 1** in the nation by Site Selection Magazine for the third year in a row and a **low cost of doing business** in biotechnology compared to other leading states
- **Favorable quality of life and cost of living** relative to other biotechnology centers, especially San Francisco, San Diego, and Boston, and a **central location in the mid-Atlantic** with close proximity to beaches and mountains
- An internationally respected model for biotechnology economic development that is built upon **cohesive industry-academic-government relationships**

to entice companies with unified and well-coordinated marketing efforts. They close the deal with meaningful financial incentives and access to a sophisticated entrepreneurial community, prominent research universities, and venture capital. States such as Texas, Georgia and Maryland have become legitimate alternatives for companies seeking new locations.

Diosynth: A success story

From zero to 650 in six years

Two businessmen from Texas approached the North Carolina Biotechnology Center one day in 1994 with a brilliant idea.

They wanted to build a biomanufacturing plant to produce genetically engineered drugs on a contract basis for biotechnology and biopharmaceutical companies. It would spare those companies the time, risk and expense of building their own plants.

The timing was right because the product pipeline was filled with biotech drugs moving through clinical trials toward FDA approval. Those drugs would need to be manufactured somewhere by someone.

The Biotechnology Center got busy to make sure the two Texans built their \$57 million plant in North Carolina and not in one of the many other states they were considering.

The Center arranged a \$3 million loan guarantee for the new company so it could buy land in Research Triangle Park. It worked with the state's banks to arrange a line of credit for construction. It helped the new company develop its business plan and introduced it to its eventual partner, Corning Life Sciences. And it referred the company to all the service provider companies, universities and government agencies in the state that would help it succeed.

Rick Hawkins, one of the company's two founders, said at the time that North Carolina had "created the finest environment for the nurturing and development of biotechnology companies in the world today. There's no question about it."

Echoed his co-founder, Dr. Chip Scarlett: "We spent months looking all over America for the right place to put this company. We met many people and were offered many inducements, but nowhere did we meet the same combination of wisdom, savvy and know-how that we found here in North Carolina."

The company, originally known as Corning BioPro and later as Covance Biotechnology Services, built a 109,000-square-foot plant that opened in 1997 with about 100 employees. The business became so successful and expanded so quickly that it was bought by the Dutch conglomerate Akzo Nobel in 2001 for about \$190 million.

Today, the company, called Diosynth RTP, has more than 650 employees at multiple sites in the Research Triangle area and continues to expand and add jobs to keep pace with the burgeoning biotechnology industry. Company executives said in October 2003 that Diosynth would invest \$100 million or more in plant expansions in the Triangle area within the next few years.

And, the competition extends far beyond state borders, particularly for new biomanufacturing plants. Among North Carolina's fiercest competitors for biomanufacturing and pharmaceutical manufacturing jobs are Ireland and Singapore. Both countries are home to a long and growing list of major pharmaceutical and biotechnology companies.

North Carolina is at the forefront of states and nations best poised to reap the economic benefits of biotechnology. To remain there, the State must pursue strategies that give it a competitive advantage in attracting and growing life sciences companies. It must also pay close attention to the needs of companies already doing business in the state to ensure they are successful and can continue to expand in North Carolina.

Pursuing opportunities

A company's announcement that it will build a new facility in a particular location typically represents the culmination of a lengthy and highly confidential process. Site-selection decisions are not made overnight, but once they are made there is usually little opportunity to change them. The best time to influence these projects is far in advance of their initiation, and the best way to influence them is through aggressive, targeted relationship development and marketing strategies.

For the largest projects, companies often engage site-selection consultants who compare the companies' requirements with available locations and narrow down the choices to a manageable number for more in-depth consideration. Fortunately, North Carolina is widely recognized among companies and site-selection consultants as a favorable location for life sciences industry investment, and is usually in the running for new site locations.

To ensure North Carolina is favorably considered for every significant project, however, a proactive approach is needed. The State must identify companies likely to require additional capacity and then introduce them early to North Carolina's

assets. Such an approach will require leadership, expert staffing and marketing resources, and meaningful financial incentives.

Empowering the Department of Commerce

North Carolina is fortunate to have a well-developed and comprehensive network of economic development professionals whose work is critical to the State's effectiveness in attracting biotechnology business. Local economic developers, public and private, are often an important source of information about what is available in their community to support a particular recruitment. They can call on local relationships and resources to facilitate recruitment activities.

However, in order to move quickly, efficiently and with one voice for the entire state, it is essential to empower a single organization with leadership for identifying company recruitment prospects and marketing the state's assets to them. As the State's lead agency in economic development, the North Carolina Department of Commerce is best suited to this task. The Commerce Department in turn should work closely with the Biotechnology Center, regional economic development partnerships, and local economic developers to fully leverage all available expertise and resources for each biotechnology opportunity and determine which areas of the state best match the candidate company's needs.

Establishing itself as a leader in the attraction of life sciences companies will require several new staff for the Commerce Department. The best way to seek new business is to hire experts in biotechnology and biomanufacturing and locate them not only in Raleigh but also in small offices in other states and countries that have large concentrations of likely prospects. Countries in Europe and Asia routinely employ this recruitment strategy. North Carolina could be one of the few states to apply it domestically and send a powerful message about its commitment to being a leading site for biomanufacturing. North Carolina has a superb opportunity to capitalize on its recent \$64.5 million commitment to the statewide workforce training network as a major draw to the state for both pilot- and large-scale biomanufacturing companies.

Adding biotechnology staff to existing Commerce Department offices in Europe and Asia would also encourage new opportunities for international collaboration in biotechnology that extend far beyond the attraction of foreign companies to North Carolina. Over time, as the industry continues to grow and consolidate, it is likely that successful companies will need distribution as well as manufacturing and R&D capabilities in Asia, Europe and North America. The potential value of a collaboration forged between representatives on the three continents could be great. North Carolina has a history of successful international partnership in biotechnology and is a highly sought after partner for two-way collaborations with both European and Asian countries. Advancing the concept to a tri-lateral collaboration would be highly innovative and potentially yield productive research and business-development opportunities for North Carolina's biotechnology community.

Marketing North Carolina

In addition to staff experts, the Department of Commerce will require substantial funds to develop and market a brand for North Carolina's life sciences "product." It may wish to build on the "North Carolina: State of Minds" campaign or embark on something more specific to biotechnology and life

sciences. In either case, North Carolina has a great story to tell, and it needs to do so broadly and confidently. This is a critical time in biotechnology economic development worldwide. To effectively secure a leadership role in biotechnology recruitment, North Carolina needs to have an effective presence at every major worldwide industry event and in industry-related meetings where high-level decision-makers are present.

The development of cost-effective, targeted marketing campaigns to attract biotechnology, biomanufacturing and other life sciences companies to North Carolina will require a comprehensive inventory of all the state's relevant assets available to all who are engaged in economic development. Assets in competing regions should be tracked as well. For every region of the state, the inventory should include, for example: industrial sites and buildings for biomanufacturing; research capabilities of public and private universities and federal laboratories; workforce training initiatives; region-specific advantages; potential strategic partners; favorable governmental policies; and access to risk capital and other financial assets.

Closing the deal: creating competitive financial incentives

In addition to expert staff, satellite offices around the world, and a targeted marketing strategy to sell North Carolina, the Department of Commerce needs access to competitive financial incentives to close deals.

Financial incentives are crucial to level the playing field in the global competition for biotechnology and biomanufacturing business. The Department of Commerce needs sufficient funds and flexibility to structure deals that are in the best interest of the state. While the specific nature of the incentives and the criteria for their use can be debated, there should be strong consensus for having competitive financing mechanisms for recruitments that bring new jobs in biotechnology and biomanufacturing. Eventually, states may deemphasize such mechanisms as a way to attract companies; but for now, such mechanisms are widely used and are expected. North Carolina must either match what competitors are offering or develop more innovative ways to recruit companies.

One creative mechanism proposed for attracting pilot-scale biomanufacturing companies to North Carolina is the establishment of a State-backed revenue bond authority that would provide access to debt financing for emerging companies wanting to build biomanufacturing plants in North Carolina. Such a revenue bond authority would also support company retention in North Carolina because several young biotechnology companies in the state are moving into the manufacturing phase of their development.

Addressing the needs of bioscience businesses already in North Carolina

An extremely important but often overlooked opportunity for new job creation is in growing the companies that are already located in North Carolina. Fortunately, some of the largest life sciences companies in the state have recently announced plans for expansion. Others, however, particularly the

emerging biotechnology companies, are struggling to implement their business models in an economic environment that has made it difficult to raise sufficient capital to support their research and development programs.

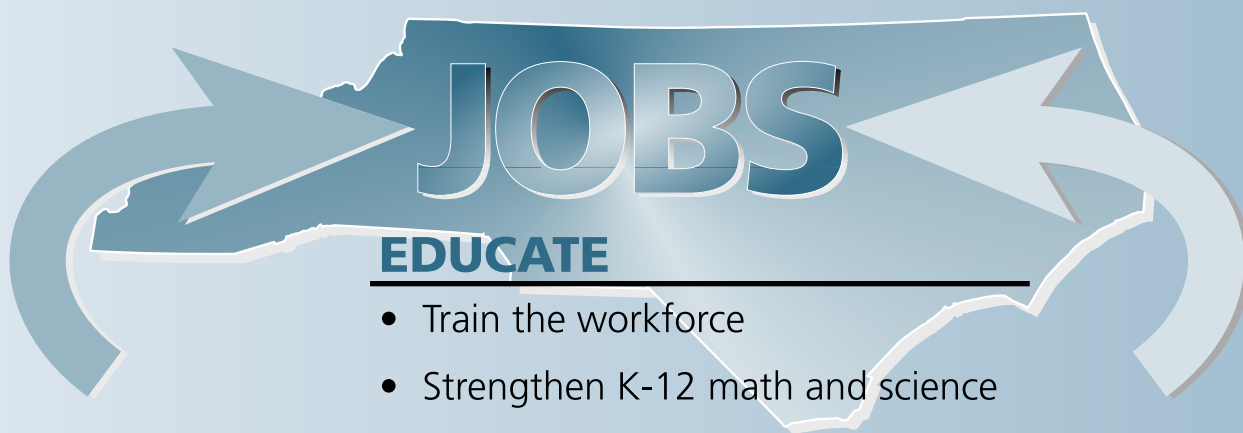
Challenges abound for most all life sciences companies, irrespective of size or scope. Helping those companies succeed and grow should be a high priority.

Recruit and Grow Companies: Recommended Strategies

Empower the Department of Commerce.		
24	<i>Provide adequate staff to the North Carolina Department of Commerce to enable it to pursue aggressive recruitment activities.</i>	The Commerce Department should hire several new biotechnology developers, with at least two based in North Carolina and the others located in states and countries with large concentrations of potential recruitment targets. For example, small satellite offices should be established in California and Massachusetts (or New Jersey), collectively home to well over half of the country's biotechnology companies, and other analysts should be located in Department offices in Asia and Europe. These biotechnology analysts will better enable the Department to proactively identify recruitment prospects that represent a strategic fit for North Carolina, including new construction, relocations and expansions. Additional staff will also make it possible for recruitment opportunities among emerging R&D companies to be identified, triaged and pursued. These smaller firms are typically easier to relocate than larger companies, and in North Carolina's supportive atmosphere they can grow and create jobs.
25	<i>Evaluate opportunities to forge international partnerships strategically valuable to North Carolina's recruitment efforts and the state's biotechnology community.</i>	North Carolina is internationally regarded for its early visionary leadership in pursuing biotechnology as an economic development strategy and the programs it has put in place to make this strategy a reality. The state has a history of effective international partnerships in biotechnology, including most notably its five-year relationship with the German state of North Rhine-Westphalia. European states and nations, as well as several in Asia, are eager to forge partnerships with North Carolina. Given the growing need of life sciences companies for capabilities and relationships in Asia and Europe, careful thought and attention should be given to opportunities to build collaborations that extend beyond two regions and perhaps encompass representatives of all three parts of the world. While complicated to negotiate and maintain, such collaborations could yield great business opportunities and further establish North Carolina as an international thought leader in biotechnology economic development.
26	<i>Establish a Hot Opportunities Team to coordinate the State's recruitment of "hot" company prospects and retention of companies at risk of leaving North Carolina.</i>	North Carolina must act aggressively and swiftly at the earliest stage of recruitment opportunities. A joint "Hot Opportunities Team" from the Commerce Department and the Biotechnology Center needs to analyze each prospect's scientific and business needs and coordinate presentations of the particular mix of North Carolina resources that will best entice the prospect. Appropriate representatives from North Carolina's biotechnology community should be brought into the campaign early. Examples include academic researchers in relevant specialties, potential partners, venture capitalists, architects, engineers and regional economic developers. Companies that have prospered in North Carolina can present their success stories. The Hot Opportunities Team must also be able to call on the Governor, Council of State, General Assembly, the North Carolina Community College System, and the UNC System. The goal is to make responding to significant recruitment opportunities one of the State's highest priorities.

Recruit and Grow Companies: Recommended Strategies

Market North Carolina.		
27	<i>Provide adequate funding to the Commerce Department to support the creation and execution of targeted marketing strategies that effectively sell North Carolina's life sciences assets.</i>	To many outsiders — as well as many insiders — North Carolina's biotechnology identity begins and ends with its flagship research universities, Research Triangle Park and large companies such as GlaxoSmithKline. There is less awareness of the community colleges and regional universities, the state's prominent agricultural biotechnology presence, the world's largest concentration of contract research organizations operating in the state, or recent innovative efforts to develop a biomanufacturing workforce. Developing a strong brand for all of North Carolina's life sciences assets and marketing that brand effectively at venues worldwide are essential to attracting companies to the state.
Close the deal: create competitive financial incentives.		
28	<i>Create a special incentive fund for major life sciences company recruitments.</i>	This fund should be reserved for deal-closing incentives to life sciences companies making investments in North Carolina of at least \$150 million.
29	<i>Fully fund the One North Carolina Fund.</i>	This fund should be established at a level of at least \$15 million per year to support its mission of job creation across rural and urban North Carolina counties.
30	<i>Lift restrictions (or provide exceptions to limits) on North Carolina's Job Development Investment Grants.</i>	The current cap on these grants is set at \$10 million per year for a total of 15 companies. However, since these grants can only be used in cases where the economic benefits to the State exceed the costs of the programs, a strict limitation is counterproductive to the program's goals. The grants pay back to companies a portion of the State tax they pay on employee withholding taxes. The money paid back is new money that new or expanding companies will have earned; therefore, there is no up-front cost to the State.
31	<i>Support financing for companies building biomanufacturing plants in North Carolina through credit-enhancing vehicles.</i>	Permitting the state to underwrite, or issue letters of credit for, a percentage of long-term loans for facility construction and equipment purchases by new and expanding companies would help mitigate some risk entailed in bank loans in the pre-manufacturing period of company development and ease access to capital. Providing access to debt financing to help fund the development of pilot-scale manufacturing plants is one of the most innovative and potentially effective ways that North Carolina can recruit emerging biomanufacturers to the state. Equally important, this approach would help retain jobs in North Carolina because several emerging biotechnology companies in the state are moving into the manufacturing phase of their development.
Address the needs of bioscience businesses already in North Carolina.		
32	<i>Survey the status and needs of biotechnology, biomanufacturing and other life sciences companies located throughout the state.</i>	Net job growth will only result if the State's recruitment efforts are balanced with a well-coordinated plan to keep North Carolina companies and jobs in the state. North Carolina currently has no consistent strategy for handling in-state companies that are being recruited to other locations or that are thinking of leaving for other reasons. Without a coordinated, proactive approach, retention efforts are unlikely to be effective. Working with local economic development agencies, the Commerce Department should survey biotechnology and biomanufacturing companies to identify those at risk of leaving the state so their issues and concerns can be addressed.



Train the Workforce

A well-qualified labor pool is essential for North Carolina to grow its life sciences industry. The state must address several challenges if it is to prepare a workforce to support both R&D and manufacturing:

- The wide spectrum of jobs. The workforce in biotechnology-related companies includes people with community college certificates and those with Ph.D.s, in specialties ranging from industrial process control to genomics.
- The need for more mid-skilled workers — those who have particular technical skills in addition to a basic foundation in science.
- The need for new and experienced employees to continue their education at all levels.
- The broad distribution of companies across the state.
- The sporadic nature of job growth. New jobs are created unevenly at different locations.

“If you don’t have the trained work force, you aren’t going to get industry to move in.”

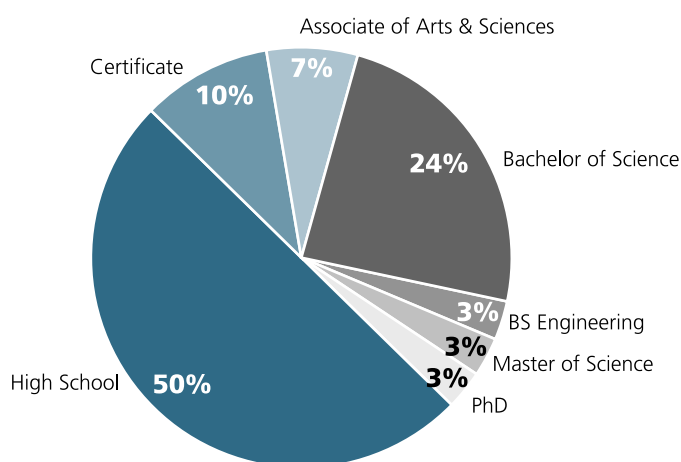
— HAL PRICE, FORMER GENERAL MANAGER, BIOGEN IDEC, RESEARCH TRIANGLE PARK

The R&D workforce

The research and development workforce grows largely from the state’s universities. Most employees in this area have BS or post-graduate degrees, and there are jobs for laboratory technicians with AAS degrees as well. Biotechnology is an interdisciplinary industry encompassing most of the biological sciences, as well as chemistry, computer science, mathematics, pharmacology, chemical engineering and other fields.

University graduates not only work for established companies, but are also a vital part of the entrepreneurial process. The acquisition of entrepreneurial skills needs to be part of their education. Researchers need also to understand production processes and the federal regulations governing pharmaceutical manufacturing in order to move new products out of the laboratory and into manufacturing.

The Biomanufacturing Workforce



Current educational profile

Biomanufacturing: a new growth industry and a strategic focus

Biotechnology is not only a set of tools for research; it is also employed in manufacturing. The newest biomanufacturing technology is the growth of animal cells to produce proteins that have therapeutic value. These new kinds of drugs are called biopharmaceuticals. Many biopharmaceutical drugs are currently in the development pipeline, awaiting FDA approval, and the manufacturing of these new drugs will create many new jobs.

The growth of biotechnology from research to large-scale manufacturing has important implications for the jobs created. First, the total number of employees increases as a company moves from research and development to commercial-scale manufacturing. Second, while research requires more Ph.D.-trained

State embarks on bold initiative in workforce training

A \$64.5 million investment by the Golden LEAF and key biomanufacturing companies will provide an integrated system of workforce training for North Carolina's biomanufacturing and pharmaceutical industries. This innovative and sweeping initiative will establish North Carolina as a worldwide leader in workforce development for biotechnology.



BioWork students at Vance-Granville Community College

The centerpiece will be a pilot-scale biomanufacturing plant for hands-on training at North Carolina State University's Centennial Campus. The facility will be shared by the UNC System and the Community College System.

Other elements will include a BioNetwork of specialized centers on selected community college campuses across the state and specialized undergraduate and graduate programs at a dedicated facility at North Carolina Central University.

Announced in August 2003, the initiative is being coordinated by the Biomanufacturing and Pharmaceutical Training Consortium, a partnership of the UNC System and the Community College System. Industry leaders are playing a major contributing role.

The pilot plant at NCSU will provide realistic workplace training for students at all levels as well as employees already working in the industry. To emulate the FDA-regulated environment in the pharmaceutical industry, hands-on training will be combined with work that teaches students Good Manufacturing Practices. This is essential because companies in this highly regulated industry can provide only a few internships for students.

Degree and non-degree education programs developed by the participating institutions will support curriculum development at other universities and community colleges around the state.

employees, manufacturing employs more workers with community college degrees or certificates; or high school graduates with appropriate manufacturing or military experience and some additional education. Third, as the methods of biotechnology are applied in other industries, the number of workers needing these skills increases.

Many biomanufacturing skills are transferable to other industries.

The biopharmaceutical area of the biomanufacturing industry is poised for significant growth over the next several years and is therefore a main focus of recommendations in this strategic plan. Biomanufacturing is also the focus of an historic investment by the Golden LEAF to support workforce training for this industry. Skills needed for biomanufacturing are transferable to other industries. People with education and experience in this field can find employment opportunities in the pharmaceutical industry as a whole, as well as chemical manufacturing, food processing, and the manufacture of cosmetics and natural products.

There is an especially close link between the biomanufacturing industry, the majority of which makes biopharmaceutical products, and the rest of the pharmaceutical industry, which makes drugs of other kinds and diagnostic products. This is why the Golden LEAF-funded training consortium is intended to support both biomanufacturing and pharmaceutical manufacturing.

The critical role of community colleges

As shown in the pie chart on the previous page, 67 percent of the employees in biomanufacturing and pharmaceutical manufacturing have less than a baccalaureate degree — and thus are appropriately trained in the community colleges. The Community College System is the backbone of workforce training for the state, is asked to

provide an increasing share of baccalaureate education through college-transfer programs, and is a key resource for rural economic development. Yet the System receives only 8 cents of every dollar that North Carolina spends on education.

Therefore, one of the strategic imperatives recommended in this plan is to provide resources to the Community College System to implement

biotechnology-related programs, and to ensure that every college can lay the foundation for biotechnology or other high-tech economic development by having well-equipped science teaching facilities. The investment requested here is intended to complement the Golden LEAF investment by providing more local options for hands-on training across the state, and improving basic infrastructure across the system to support relevant science and technology education. The capacity of the system should be extended to fulfill the needs of this industry in all areas of the state.

The biomanufacturing workplace

Training is critical. A single batch of a new biopharmaceutical product can be worth millions of dollars. One wrong move by a technician or a failure to document one detail of production can make the batch unfit for sale.

All pharmaceutical manufacturing, including biopharmaceutical manufacturing, is tightly regulated. Good Manufacturing Practice (GMP) guidelines govern every aspect of the process to the smallest detail. It takes time for new employees to acquire the mind-set and behaviors required for compliance. Learning GMP systems and habits accounts for half of on-the-job training time, which averages nine months.

Because of this, biomanufacturing employers hire people with prior experience in the pharmaceutical industry whenever possible. This often means hiring each other's employees. This is still a fundamental recruitment practice even though companies acknowledge that it limits their ability to grow. In 2002 pharmaceutical companies filled less than 15 percent of entry-level job openings with new college graduates. This is the major challenge in developing programs to prepare graduates for pharmaceutical or biomanufacturing careers. Training time affects the bottom line for companies. An effective workforce-development system ultimately reduces on-the-job training time by producing more competitive job applicants and providing training for new hires.

Why new graduates often aren't competitive job applicants

The Biotechnology Center has conducted extensive surveys of employment needs in the biomanufacturing and pharmaceutical manufacturing industries. (The latest one, *Window on the Workplace 2003*, is available on the Biotechnology Center's Web site, www.ncbiotech.org.) In these studies, employers consistently find sig-

Life beyond textiles: retraining for a biotech job

Judy Watkins knew that retraining herself for a science career would be difficult, but at times it was downright daunting.

She found herself in a biotechnology classroom at Alamance Community College with students at least 10 years her junior. Watkins also had to revisit her high school chemistry and algebra classes to guide her through the advanced courses.

But she kept her eye on the prize: a new career working with microscopes.



JUDY WATKINS

While taking her classes, Watkins knew this was a second chance to work with science. She'd had to shelve those plans years ago to raise six children and work the third shift at the Collins and Aikman Corp. textile plant in Granville County.

"I don't know how to explain it, but I wanted to work with a microscope," she said.

Watkins' opportunity came when plant officials announced they would lay off about 400 people in 1987. Through an agreement

with the State and her former employer, Watkins enrolled in the two-year biotechnology program at Alamance Community College while she received unemployment checks.

Watkins, then 46, studied topics foreign to her including the metric system and physics. She performed experiments such as removing caffeine from coffee. But she faced yet another challenge: adapting to a challenging new field filled with younger people.

"We have to build up confidence before we can begin training," explained William H. Woodruff, head of Alamance's biotechnology department. "And as she became more confident, she built on that success."

Watkins made the dean's list every quarter and even earned the award for most improved student. In 1989 she landed an internship in a media preparation lab with Syngenta Biotechnology in Research Triangle Park. A year later she became a full-time employee, and in 1998 she became manager of the department that prepares reagents and sterilizes equipment used by the company's scientists.

Watkins, now 60, remembers one day looking around the laboratory she calls home and thinking to herself, "I feel like I have died and gone to heaven."

nificant deficiencies in college graduates that limit the graduates' employability. Graduates are often:

- Unaware of how the pharmaceutical industry works, so they do not understand how what they do on the job can affect other aspects of the manufacturing process
- Unaware of the work habits required in a regulated environment
- Lacking in interpersonal/team skills and project-management abilities, as well as oral and written communication skills
- Lacking in practical laboratory experience, problem-solving skills and ability to design experiments.

While many educational programs provide at least part of the required background for new employees in pharmaceutical or biopharmaceutical manufacturing, few, if any, provide the complete package. There is a strong need to establish comprehensive and targeted training programs.

Designing effective workforce education and training programs

The need for prior industry experience in new hires makes it clear that student internships are ideal preparation. However, opportunities for student experience in the pharmaceutical industry are limited, in part because FDA regulations make it difficult for companies to implement them. More workplace or simulated experiences should be made available to students by:

- Finding incentives for companies to offer more internships or developing alternative experiences such as job shadowing
- Making it a priority for the Biomanufacturing and Pharmaceutical Training Consortium pilot plant at North Carolina State University to create as many internships as possible
- Making the classroom more like the workplace by incorporating industry orientation, GMP training, and career skills practice into science and technology curricula.

Making learning conveniently accessible

To maximize employment opportunities for all North Carolina citizens and make the state's companies more profitable, relevant education must be available to anyone, anywhere in the state, at any time. To do this, several approaches are possible:

- Expanding distance-learning resources
- Offering more courses in evenings and on weekends and making use of community-based satellite locations
- Modularizing curricula so people can acquire particular skills in a short time as needed, but also count that learning toward a degree or certificate
- Deploying mobile laboratories to reach outlying community colleges and companies.

Train the Workforce: Recommended Strategies

33	<i>Fund selected continuing education programs at the community colleges at the same level as curriculum programs.</i>	Continuing education courses can be quick and flexible to implement, and are the foundation of much training for industry. An example is the <i>BioWork</i> course. However, colleges get a reduced level of funding for these courses as compared to degree program courses. The funding level is not adequate to support even basic hands-on science courses that are needed to support the life science industries — so open-enrollment <i>BioWork</i> courses run at a loss.
34	<i>Provide an Innovation Fund for the Community College System to support biotechnology initiatives.</i>	Most funding streams are FTE-driven, and it is difficult for colleges to renovate and equip laboratories or hire faculty for program development in advance of actual enrollment. The proposed fund should be used to start and enhance biotechnology related programs, complementing the Golden LEAF funding for the Biomanufacturing and Pharmaceutical Training Consortium, and providing support for faculty to work with industry in developing new programs.
35	<i>Upgrade community college science and engineering technology laboratories.</i>	Relatively few colleges have teaching laboratories suitable for biotechnology-related science. Teaching basic science is the first need in preparing the workforce for this industry anywhere in the state. Each college should have at minimum two well-equipped science laboratories and one well-equipped engineering technology laboratory for use in college transfer or curriculum programs, or customized industrial training.
36	<i>Provide continuation funding for the Biomanufacturing and Pharmaceutical Training Consortium.</i>	The value of the initial investment by the Golden LEAF to build a training system without parallel in the nation would be substantially diminished if the UNC System and the Community College System do not have operating funds to maintain the facilities and programs.
37	<i>Provide professional development opportunities for faculty.</i>	Most faculty have little or no acquaintance with industry, a key reason why graduates are often ill prepared for employment. Instructors at all levels should have up-to-date knowledge of industry's regulatory and operational environment as well as the relevant applied science and technology.
38	<i>Develop and implement industry-approved certifications.</i>	For jobs that require college-level education, degrees are a necessary but not entirely sufficient qualification for employment in biomanufacturing. Certifications for different kinds of positions in industry could sharpen educational programs. Taking the lead to create such certifications would build global recognition for North Carolina's innovation in workforce development.
39	<i>Provide support for innovative program development.</i>	Competitive grants administered through the Biotechnology Center can provide funding for curriculum development and equipping teaching laboratories at any college or university. Strategic investments are needed to support growth of the best programs that would most clearly support workforce development.
40	<i>Expedite the implementation of articulation agreements between community colleges and universities.</i>	Students and incumbent employees need to be able to accumulate professional credentials over time and make seamless transitions from one institution to another in a universally accessible educational system. Although a comprehensive articulation agreement between the UNC System and the Community College System covering general education and pre-major programs is in place, implementation is incomplete. Moreover, there is no universal articulation agreement covering Associate of Applied Science degrees.

Train the Workforce: Recommended Strategies

<i>41</i>	<i>Provide basic curriculum resources about the industry.</i>	With advice and leadership from industry, the Biotechnology Center should coordinate the development of modules that provide educators at all levels with basic information on the range of careers in biotechnology as well as an orientation to biomanufacturing and GMP.
<i>42</i>	<i>Establish a Biotechnology Workforce Advisory Council.</i>	Input from the industry is essential. While many institutions and departments have their own advisory groups, there should be a high-level Biotechnology Workforce Advisory Council composed of key industry and education leaders and staffed by the Biotechnology Center. This council would advise on workforce recruitment and training needs, mobilize industry support and input, and act as a focus of communication among education programs statewide. Over the next two years, the Biotechnology Center should work with educational institutions and industry to establish the recommended statewide Advisory Council.

Strengthen K-12 Math and Science

The quality of K-12 schools is directly related to economic development in an industry such as biotechnology, for two reasons:

- Quality of public education is a key factor in recruiting new businesses, especially those that employ highly educated professionals.
- Schools influence students' career choices and their attitudes toward learning and entrepreneurship. It is during the K-12 years that students acquire basic skills and either acquire or lose interest in science and science-based careers.

Where North Carolina is and where it needs to be

Two decades of leadership, investments in schools and innovative reforms have greatly improved North Carolina's national standing in education, according to many performance indicators. The state has come a long way since the early 1980s, when it ranked near the bottom of nearly every educational indicator. But in a highly competitive environment, North Carolina's advantage relative to other states is a moving target, and constant investment is needed to retain the edge.

The National Assessment of Educational Progress (NAEP) tests show that among the 50 states, North Carolina eighth graders rank only 23rd in science. Even on tests where North Carolina ranks in the top half of the country, only about one in three students achieves scores at the proficient level. Achievement by minority students on math and science tests lags significantly.

Over the next 10 years, the State should aim to increase by 25 percent the number of students scoring at the proficient level on the NAEP tests. This will put North Carolina among states performing significantly higher than the national average. North Carolina also needs to increase the number of high school graduates entering community college or university programs that will prepare them for careers in life-science industries.

Critical factors in the educational environment

Any innovation and improvement in schools in North Carolina and across the nation must take place amid three major factors in the educational environment:

- The shortage of qualified teachers, especially in math and science, is critical. Over half the students in North Carolina middle schools have teachers without a college major or minor in the subjects they teach. Teacher retention is equally important. In the last five years, an average of nearly 13 percent of North Carolina's teachers (more than 11,500 teachers) have left their positions each year.
- There is unequal distribution of resources to support schools in wealthier versus poorer districts.

"North Carolina public schools have made significant strides in academic achievement over the past decade. To participate competitively in the global economy, our young people need a strong focus in all academic areas, and especially in mathematics and science. These two subjects are at the heart of many of the high-growth industries that now call North Carolina home. Biotechnology is one of those industries that hold great promise, economically and socially. Our students need to be prepared to participate in this exciting endeavor."

— STATE SUPERINTENDENT
MIKE WARD

- The federal No Child Left Behind legislation will make great demands on school performance and may make teacher shortages more acute. However, this legislation presents an opportunity to improve science education at the elementary and middle school levels and close achievement gaps for minority students.

NC-ISE gets K-8 students ‘doing science’

For Scott Maxey, an Alderman Elementary School student in New Hanover County, understanding “plant growth and development” became much more interesting when he started doing the cross pollinating himself with a little help from one of nature’s most prolific pollinators.

“My favorite thing was when we pollinated flower blooms with bees,” he said.

Educators statewide hope to hear that enthusiasm from all students who benefit from the North Carolina Infrastructure for Science Education (NC-ISE) program. Launched in 1998, the program is based on research by the National Science Resources Center that identified seven school systems nationally that had exemplary science programs for five or more years. These schools shared five common elements for success:

- alignment with standards-based curricula
- continuing professional development for teachers to support science content and building confidence in guiding student investigations
- materials support for student experiments through the use of inquiry-based kits deemed effective at teaching science
- support from community, school and district-level administration
- student assessment that is based on learning objectives in the curriculum and how students are taught

Research has shown that student writing improves significantly with continued experience with inquiry-based science. Other studies indicate that the achievement gap between minority and non-minority students closes with continued exposure to an inquiry approach. Presently, about two-thirds of North Carolina’s school districts participate in NC-ISE.

Bob Maxey, former math and science teacher who initiated the program in New Hanover County, believes “students must hold science in their hands before they can hold it in their minds.” If so, the NC-ISE program can play a critical role in providing the necessary support structure to bring hands-on, inquiry-based science learning to students across the state.

To achieve significant improvement in math and science education in general, as well as to prepare students for biotechnology careers, will require communities and school systems that recognize the importance of science and math education, teachers who are well-prepared and supported, and career education that is better integrated in the curriculum.

Taking advantage of key opportunities

North Carolina has two immediate opportunities that can provide key advantages in strengthening biotechnology-related education.

The North Carolina Infrastructure for Science Education Program

Established in 1999, the North Carolina Infrastructure for Science Education Program (NC-ISE) is a partnership among the Department of Public Instruction, industry groups, and branches of the UNC System. In a cost-effective way, this program educates teachers and school administrators who form partnerships within their communities to support science education. Teachers receive supplies to implement nationally recognized curricula. These measures have led to significant improvements in student learning in other states, and reduced achievement gaps for minority students.

The Gates Foundation grant to create innovative schools

The Bill and Melinda Gates Foundation grant to North Carolina, announced in August 2003, provides \$11 million in seed funding to start new schools or reorganize existing schools in new ways to enhance student achievement. Different types of schools will be created, each with a unique design and/or career specialization. The Gates Foundation grant provides a great opportunity to establish schools specializing in biotechnology that could serve as regional models and resource centers for teachers. Such schools should lead to higher graduation rates, particularly for at-risk students; and a higher percentage of students who either pursue higher education or who enter the workforce directly in the school’s field of specialization or related areas.

Teacher preparation

Investing in professional development for science teachers is one of the most strategic investments North Carolina can make to support biotechnology education. While there are many areas in which teacher training is needed, two priority needs are outlined below.

Inquiry-based science teaching methods

Traditional lecture methods don't work well for teaching science. Inquiry-based instruction, in which students learn through their own experimentation, increases student performance in science as well as math and writing. Teaching methods such as this should be the norm rather than the exception as they have been in many schools. However, education majors rarely see inquiry-based approaches modeled in the science classes they attend, or even during their student teaching. Requiring proficiency in good science-teaching methods as part of State accreditation should bring about positive changes in how new teachers are prepared.

Enhancing professional development experiences

North Carolina is fortunate to have several organizations that provide teacher-training workshops in biotechnology. The Biotechnology Center, in partnership with the state's universities, has sponsored workshops for more than 1,100 teachers in 98 counties since the late 1980s. Other organizations that provide professional development include:

- The Program for Minority Advancement in the Biomedical Sciences, which sponsors the now famous Destiny Bus — a unique and valuable science education resource for the state.
- The North Carolina Association for Biomedical Research, which reaches hundreds of teachers a year through workshops that highlight cutting-edge biomedical research.
- Science House at North Carolina State University, which has for years supported teachers as well as students in a variety of hands-on activities, including applications of biotechnology.
- Duke University, which offers two-week courses in molecular biology topics for teachers.
- The Kenan Fellows Program supports teachers in curriculum development projects and provides leadership training.
- The North Carolina School of Science and Mathematics has excellent outreach programs for teachers in rural schools.

These resources are excellent, but experience has shown that many teachers need much more follow-up support before they gain the confidence to implement new and complex hands-on laboratory activities in their classrooms. Local or regional teacher-support networks should be established to provide on-going support.

"Students must hold science in their hands before they can hold it in their minds."

— BOB MAXEY, FORMER NORTH CAROLINA MATH AND SCIENCE TEACHER

Career and Technical Education

About two-thirds of the workforce in biomanufacturing and pharmaceutical manufacturing has a high school diploma with appropriate manufacturing or military experience or community college education. Therefore, Career and Technical Education (CTE) in the K-12 schools is strategically important. Biotechnology-related CTE courses at both the middle school and high school are vital to encouraging students to pursue careers in biotechnology and should be supported.

Workshops train 1,100 teachers in 98 counties

For the last 16 years, the North Carolina Biotechnology Center has sponsored summer workshops for teachers who want to give their students hands-on biotechnology lessons. The program has reached more than 1,100 teachers from middle schools, high schools and community colleges in 98 counties.

“Biology comes alive for students when they participate in research methods used in labs around the world,” said workshop graduate Zoe Welsh, a biology teacher at Leesville Road High School in Raleigh. “Even loading a gel with a micropipette shows students that biology is much more than microscopes and prepared slides — biology is a pursuit, not a destination.”

The workshops, held at colleges and universities around the state, let teachers learn from college faculty and other experienced “master teachers” how to provide hands-on instruction in biotechnology. Teachers receive free room and board, a daily stipend, continuing-education credits and a copy of a textbook developed by the Biotechnology Center.

The Biotechnology Center helps workshop graduates apply their new knowledge in the classroom by providing or loaning laboratory supplies and equipment.

“The borrowing of equipment and procuring of supplies from the Biotechnology Center have made it possible for us to offer an advanced biotechnology course,” said Pamela Johnston, a biology teacher at Alexander Central High School in Taylorsville. “The resources provided by the Center give our students the opportunity to be on the cutting edge of technology and the ability to compete on a level playing field with students from larger school systems in the state.”

Supporting teachers is critical because they give students hands-on experience in science versus only reading about science. Research shows this is how students learn and remember best.

Providing the tools

Teachers need the opportunity both to develop curricula and to access curricula developed by others. They need equipment and supplies for laboratories so they can give their students hands-on activities.

With increased funding, the Biotechnology Center can supply these needs for teachers across the state. The Biotechnology Center’s Education Enhancement Grants program can support major educational projects, such as implementation of new programs in an entire school system, while its Mini Grants can help individual teachers revise courses and set up laboratories. These grant program budgets are currently so low that good proposals cannot be fully funded. The Biotechnology Center’s laboratory supplies and equipment programs for teachers also need to be expanded. These programs provide hands-on biotechnology teaching resources free to any teacher in the state.

Strengthen K-12 Math and Science: Recommended Strategies

Take Advantage of Key Opportunities		
43	<i>Support and expand the North Carolina Infrastructure for Science Education.</i>	This program is a cost-effective way to give individual school systems the tools and know-how to provide effective science education at the elementary and middle school levels. With additional funding from the state, the State Board of Education, the Department of Public Instruction, and the UNC Center for School Leadership Development should expand the program to all school systems and to high schools.
44	<i>Capitalize on the grant to North Carolina from the Gates Foundation to create innovative schools for biotechnology.</i>	This grant will help establish new schools organized in creative ways to stimulate student achievement, reduce drop-out rates, and enhance training for technical careers. Some of these schools should specialize in biotechnology. The Biotechnology Center and the North Carolina Science, Mathematics, and Technology Education Center should work with program administrators to identify potential sites and curriculum designs for new biotechnology schools in preparation for an invitational RFP process through which planning grants will be awarded.
Prepare Teachers		
45	<i>Require proficiency in inquiry-based science teaching methods for teacher accreditation.</i>	Inquiry-based and other related teaching methods lead to significant increases in science as well as math and writing scores, and build student interest in science. Such methods should be the norm rather than the exception. The State Board of Education and the Department of Public Instruction should institute this change in accreditation standards, which can enhance the preparation of science teachers.
46	<i>Enhance professional development experiences for teachers.</i>	In collaboration with the professional development providers listed on page 71, the Biotechnology Center could establish a mentoring network of retired teachers who have experience in teaching biotechnology topics. These mentors could coach and support other teachers in implementing the hands-on laboratory activities presented in professional development workshops.
Provide the Tools		
47	<i>Strengthen Career and Technical Education curricula in biotechnology.</i>	Though state funding for middle school CTE education has been reduced, the Exploring Biotechnology course should be retained. At the high school level, the Biotechnology Center should work with the Department of Public Instruction to establish courses for a CTE biotechnology career pathway.
48	<i>Support curriculum development and provide resources for teaching biotechnology-related science.</i>	The Biotechnology Center should receive increased funding for its Education Grants programs, its laboratory supplies and equipment programs, and the development of a comprehensive Web site to provide biotechnology education resources as well as industry and employment information to schools and the community. This Web site would be a joint effort with the Department of Public Instruction and the North Carolina Science, Mathematics, and Technology Education Center.

STRENGTHEN BIOTECHNOLOGY STATEWIDE



Strengthen Biotechnology Statewide

Biotechnology will be increasingly important to the future of all North Carolinians. Its impact will be seen in the economy through new jobs, new companies, and new applications for existing industries. Biotechnology will also affect community development, as leaders and institutions apply it to their economic planning, schools, agricultural sectors, health care industries, and long-term goals. Educational and economic impact, in particular, will be seen on an increasingly diverse population and workforce, as persons from more geographical regions and minority groups are trained to work in the industry.

Biotechnology in fact now has pervasive impact throughout society. It affects science and research, investment and economic development, education and training, agriculture, manufacturing, institutes of higher education, governmental agencies and industry. With wide impact on science, the environment, and the public, this life-changing technology also brings ethical questions and implications. These issues are often without precedent and are not always easily addressed. Within North Carolina, these issues must be addressed forthrightly, to ensure public understanding of biotechnology and to instill public confidence in the safe and wise use of the technology.

Few sectors or technologies will prove so important to the economic and societal future of North Carolina as biotechnology. The evidence is already apparent. The technology has begun to affect almost every aspect of life across the state, and will do so increasingly for decades to come. As it becomes more pervasive in our lives, biotechnology will require informed, sustained, and statewide attention and leadership.

Strategies, planning, and vision for North Carolina's third decade of biotechnology development must be shaped by three broad imperatives:

- Statewide development and application of biotechnology
- Informed and strong leadership
- Attention to societal and ethical issues.

Developing and applying biotechnology statewide

The benefits of biotechnology must be brought as much as possible to all citizens and communities across North Carolina: urban and rural, rich and poor, east and west, north and south, minority and non-minority.

Biotechnology development is a statewide undertaking. The economic potential of the technology should be understood and targeted statewide. The issues of the technology should be addressed in communities statewide. Biotechnology should be effectively and realistically folded into the goals, plans, and vision of leaders statewide.

North Carolina, rich in natural and institutional resources, is uniquely able to weave biotechnology into more communities and more constituencies statewide. In addition, the movement of biotechnology from its initial research-

The richly varied cultures and geography of North Carolina yield a wonderfully varied foundation for biotechnology statewide.

intensive phase to products and biomanufacturing expands possibilities for communities stronger in areas other than science. Expanding the geographic range of biotechnology will broaden the positive impact on job creation, local economies, citizen skills, groups diverse in cultural or racial characteristics, and community vision and pride.

Lenoir location works for biotech company

Traffic jams are nonexistent. The labor force is well trained. The needed raw materials can be found nearby.

But this isn't the Research Triangle Park.

Greer Laboratories has nestled itself in Lenoir, at the foothills of the Appalachian mountains, for the last 69 years. And executives with one of the eight largest allergy-related companies in the United States do not see a need to change locations.

"We feel like there is a good work ethic here and the quality of life is good," said Bill White, director of the 100-year-old company. "We find our needs are met locally."

Greer Laboratories' main calling card is in the allergy-testing and treatment field. Major products include self-loading antigen testing kits that don't require needle sticks to test for allergies. The tests produce a slight scratch on the skin.

The company's Lenoir headquarters has provided another added benefit. Scientists and collectors can find all of the needed raw materials within an 80-mile radius to drive the company's research. The company bills itself as the largest supplier of allergic extracts in the nation.

"This happens to be a good area for collecting pollen, unless you happen to be allergic," White said jokingly.

That hasn't been a problem for the company's 210 employees, nearly all of whom live in Caldwell County, said White, himself a county native. The company operates out of seven buildings on two campuses that encompass 200,000 square feet. Plans are in place for a future expansion.

Ensuring that the benefits of biotechnology reach into every corner of the state in the next decade should be a high priority of leaders and policy-makers statewide, and of the Biotechnology Center.

A growing number of communities have resources to build biotechnology activities. All regions can target certain aspects of biotechnology, from education and training to support companies and biomanufacturing. Different regions can also build upon particular resources or niche characteristics. Biodiversity and trees can provide a unique emphasis for Western North Carolina, as can marine resources, biomedical applications, and agriculture for Eastern North Carolina. Greater Charlotte can continue expansion of biotechnology-related support companies, target the convergence of life science and information technologies, and direct financial resources to trigger company development. The Piedmont Triad can build upon its well-developed human health resources. Regional strengths statewide might include specific scientific research, preparation of a workforce, investment, incubator facilities, schools and community colleges, support services, or new capabilities in traditional manufacturing. The richly varied culture and geography of North Carolina yield a wonderfully varied foundation for biotechnology statewide.

The Biotechnology Center's *Project to Strengthen Biotechnology Across North Carolina* has begun to develop biotechnology statewide by establishing satellite offices throughout the state. Two were established in 2003, in Asheville to serve Western North Carolina and in Winston-Salem to serve the Piedmont Triad. If resources are gained, two more are planned for 2004, to serve Eastern North Carolina and greater Charlotte. Reflecting both local commitment to biotechnology and insufficiency of Biotechnology Center funds, initial financial support for the Western and Piedmont Triad offices has come from those communities, but cannot be ensured permanently.

Satellite offices reflect an important fact of economic development in biotechnology: targeted strategies can best be addressed by intensive local attention rather than from a distant and centralized location. Community leadership can more effectively be gained, long-term local economic development strategies can be crafted, and local capabilities can be better targeted.

Satellite offices assist all participants in the biotechnology community in short- and long-term activities:

- Identifying regional niches
- Estimating area capabilities and goals
- Recruiting and expanding companies
- Strengthening scientific, mathematical, educational, agricultural, research, company, and biomanufacturing capabilities
- Assisting area agencies and institutions
- Catalyzing commitment from governmental, institutional, and economic development leadership.

Government and economic development leaders across the state are correct in expecting regional gain from such activities in coming years. Expectations must be realistic, however. Biotechnology is a key tool in the tool box of economic development strategies for a community but can never be considered as the only tool for economic development. The realities of biotechnology development must be granted. Biotechnology is more complicated and costly to bring about than other, traditional sectors; activities and commitment must be sustained in the long-term; and the focus must generally be regional rather than local. Partnerships among many parties across counties are usually required to bring about biotechnology activities, companies, jobs and products.

The need is clear: biotechnology must benefit communities statewide. This will require unequivocal state policy and committed leadership.

Informing leaders

The impact of biotechnology throughout society is pervasive, as noted above. The technology is so important to North Carolina's current and future economy, competitiveness and quality of life that it must be counted among key areas of policy attention and leadership. Like other key aspects of society — education, the judicial system, transportation or electricity — biotechnology demands informed attention from the State. Like any complex endeavor, biotechnology must be developed with vision, planning and leadership.

Benefits are more likely if not left to luck; they must be brought about by deliberate attention and leadership.

Biotechnology provides a new area for North Carolina to exercise its traditionally strong ability to merge leadership, vision and practical action for major

The need is clear: biotechnology must benefit communities statewide.

Addressing the societal issues of biotechnology

Technologies throughout history have brought profound implications for humankind. Biotechnology has particularly strong impact because it affects living organisms and the natural world and must be used responsibly. Few, if any, earlier technologies have been so carefully regulated, widely discussed, or dissected for issues, questions and responsibilities.

The issues of biotechnology are remarkably wide, complex and often unprecedented. They include questions about:

- research and product priorities
- ownership and use of genetic information
- responsibilities to Third World countries
- stem cells and cloning
- possible transference of genetic traits from altered crops
- the use of animal tissues and organs for human survival
- mankind's intervention in nature
- regulatory oversight
- food safety and labeling
- environmental and cultural implications of genetically altering trees.

Confronting these and other issues and questions forthrightly with input from all viewpoints is essential to long-term success in biotechnology development. The state's institutions and citizens must be confident that biotechnology is not moving too quickly ahead of public understanding and approval. North Carolina can and should provide practical and bold leadership in addressing the issues of biotechnology so its policies serve the best interests of the state's citizens.

gain. The state has been fortunate to have local and State leaders who are aware of the state's needs and opportunities and are unafraid to address them. Astute estimations about issues, policies and goals important to the state have been made with greater than average success. New opportunities have been

Novozymes' biomanufacturing plant grows in Franklin County

Novozymes, the world's largest producer of industrial enzymes, is also known as an environmentally friendly company.

The North Carolina Department of Environment and Natural Resources named the company's Franklinton biomanufacturing plant as its first "environmental steward" in 2003 for exceeding environmental requirements.

The plant uses technology that reduces the amount of water, water filters and raw materials it uses. It has also created biological waste-treatment systems that support microbial action in breaking down waste.

Novozymes, which makes enzymes for more than 700 products ranging from detergents to ethanol fuel, has operated in Franklin County since 1979, when it was known as Novo Nordisk. The Danish company chose the Research Triangle area in the 1970s because of its higher education system, accessible airport and good quality of life.

The Franklinton plant has expanded five times, and in 1995 the company moved its sales and marketing responsibilities for the United States and Canada to North Carolina.

That decision has proven fruitful for the state because today Novozymes employs about 400 people in Franklin County and has invested more than \$250 million in its plant there, after an initial investment of \$10 million in the 1970s.

identified early, such as the State's commitment to biotechnology more than 20 years ago.

Success in biotechnology, as with any endeavor important to society, depends on strong leadership by all who govern the state and manage its institutions. Policies must serve practical outcomes; programs must be supported; resources must be allotted; and long-term, statewide outcomes must prevail over short-term solutions or partisan victories. Substantial money must be committed, even during poor economic times. Because the rewards of technology develop over many years, the fullest evidence of biotechnology leadership will likely also be seen in the long term. North Carolina, through its Biotechnology Center, was the world's first government to commit to biotechnology development more than two decades ago. The State must continue that legacy of long-term thinking, planning and acting.

Those persons responsible for the state's long-term economic vision, goals and appropriations must be informed about the opportunities, required policies, and development of biotechnology statewide. The Biotechnology Center joins other entities in providing information and ideas, and in urging new directions or strategies when required. The range of such other entities with a

place in biotechnology leadership is extensive, attesting to the importance of biotechnology to the institutions and life of North Carolina. It includes universities and community colleges, the General Assembly and local governments, the North Carolina Department of Commerce and economic development agencies, and organizations with specific roles, such as the Institute of Emerging Issues and the North Carolina Board for Science and Technology.

Attending to societal and ethical issues

Technology development has traditionally demanded attention in two broad areas: first, foundational science and research; second, development of companies, products and markets. Biotechnology requires attention to a third equally important area: ethical, societal and policy issues.

Not surprisingly, a life-changing technology yields unprecedented questions and challenges about impacts, priorities, environmental implications and use of living organisms. Fortright and informed discussion of new and at times vexing issues by many diverse parties is essential but is not always easily gained from institutions with different missions and viewpoints. Targeted new strategies and incisive leadership can encourage such discussion. An ongoing,

neutral forum for hard questions and strong recommendations is required. The Institute for Emerging Issues, established at North Carolina State University to help address North Carolina's future challenges and opportunities, is ideally suited for this role. It is well positioned to provide forums, publications, symposia, public engagement, position papers, and assistance to policy leaders.

Addressing the ethical, cultural, societal and policy issues of biotechnology is neither a luxury nor just an interesting academic experience. Doing so is a societal responsibility and an effective strategy. Attention to the implications of a technology is justifiably expected of the persons and institutions bringing that technology to the public. The strategic value of such discussion is equally important; without it, expected economic and societal benefits of biotechnology might be curtailed by uncertainty, be shaped with insufficient policy, or worse be less carefully developed. Because such attention is seldom encouraged at the state level, establishment of a committed, permanent framework will yield additional leadership for North Carolina — as well as recognition worldwide that the state is fully prepared for every challenge stemming from the development, use, and public implications of biotechnology.

North Carolina is positioned among the top five states in the country for taking advantage of biotechnology as a key economic engine. Our state also has the chance to lead the world in developing new societal institutions and the wisdom to properly manage our newfound power.

— TOM HOBAN, PROFESSOR
OF SOCIOLOGY AND FOOD
SCIENCE, NORTH CAROLINA
STATE UNIVERSITY

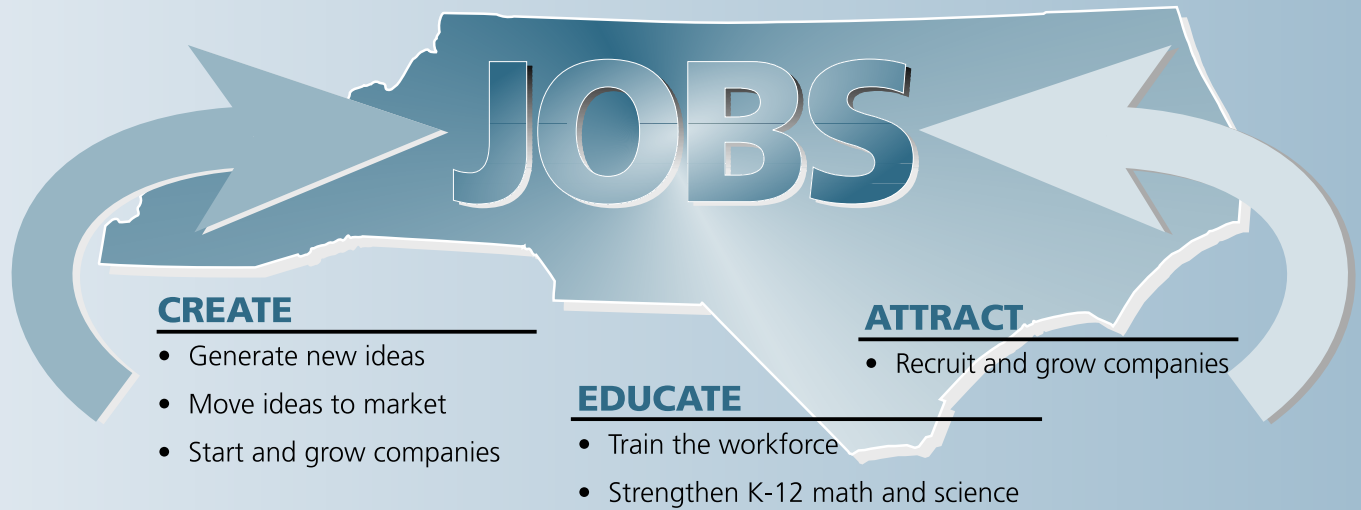
Strengthen Biotechnology Statewide: Recommended Strategies

Developing and applying biotechnology statewide		
49	<i>Assist communities statewide, particularly rural ones, to identify niche opportunities and target resources for building biotechnology-related activities.</i>	North Carolina, varied in natural and institutional resources, is uniquely able to spread a growing amount of its biotechnology development statewide. Doing so requires: realistic estimation of area capabilities and goals; recruitment or expansion of companies; strengthening of scientific, educational, support, company, agricultural and biomanufacturing capabilities; assistance to area agencies and institutions; and commitment from governmental, institutional, and economic development leadership. Results will be gained with sustained attention and appropriate strategies.
50	<i>Provide funding for the Biotechnology Center to establish and maintain permanent satellite offices statewide.</i>	Targeting biotechnology applications and development to communities statewide is feasible, but can best be accomplished with strong attention within specific regions rather than from a central, distant location. Small satellite offices of the Biotechnology Center, responsive to niche opportunities with a community-based approach and programmatic funding, will accelerate economic development in biotechnology.

Strengthen Biotechnology Statewide: Recommended Strategies

Informing leaders		
51	Charge the Biotechnology Center with leadership for North Carolina's biotechnology policies and strategies, including implementation of the Strategic Plan.	<p>Biotechnology develops from many diverse parties working purposefully together and is based on partnership among universities, community colleges, government and industry. Because the contributions and goals of these sectors are different, but must be brought to common purpose, the Biotechnology Center was established as a central focus, catalyst and partner. As such, the Biotechnology Center is deliberately positioned to assist, rather than direct or duplicate, the activities of these sectors. In addition, it is expected to have an informed and comprehensive view of the requirements, activities and goals of North Carolina's biotechnology community. In these roles, the Biotechnology Center is logically expected to serve also as a first, central voice for new ideas, suggested strategies, necessary resources and emerging areas of opportunity.</p> <p>The Biotechnology Center should be mandated to serve these roles in two main ways, annually reporting on each to the State's leadership and biotechnology community:</p> <ol style="list-style-type: none"> 1. In relation to this strategic plan, the Biotechnology Center should report about implementation activities, evaluate outcomes and recommend appropriate changes as results unfold. 2. The Biotechnology Center should recommend statewide opportunities, strategies, areas of attention, responses to issues, and responses to national and international competition. Biotechnology partners across North Carolina should be drawn upon for information, ideas and resources. The Biotechnology Center should synthesize information and advocate strategies to assist its partners.
52	Inform and engage the Governor, Lt. Governor, General Assembly, and Council of State in issues critical to biotechnology development.	<p>Biotechnology is so important to North Carolina's future economy, competitiveness and quality of life that it must receive policy attention and leadership from the highest levels. Leaders responsible for the State's long-term economic vision, goals and investments must be comprehensively and regularly informed about the opportunities, required policies, and development of biotechnology statewide. The Biotechnology Center will join other entities in providing information and ideas, and in urging new directions or strategies when required.</p>
Attending to societal and ethical issues		
53	Establish a forum at the Institute for Emerging Issues for the timely and responsible discussion of ethical, cultural, societal and policy issues of biotechnology.	<p>Biotechnology yields profound and often unprecedented questions, issues and implications. Public and private institutions, often with differing points of view, must be brought together for discussion, analysis and realistic policy recommendations. Establishing a framework in which to carefully address the issues of biotechnology is both a required strategy and a societal responsibility. Doing so will also signal North Carolina's leadership in addressing issues at the state level. Established to bridge gaps between public policy and the fields of science, engineering, and technology, the Institute for Emerging Issues is well positioned to assemble the diverse statewide institutions, agencies and voices required to address the issues of biotechnology.</p>
54	Increase funding for the Board of Science and Technology.	<p>Because science and technology are interrelated and so vital to North Carolina's economy, they require coordinated attention at the state level. Increasing the resources of the Board will enable it to better develop programs, identify opportunities, and strengthen science and technology as a foundation for North Carolina's economic development.</p>

STRENGTHEN BIOTECHNOLOGY STATEWIDE



New Jobs Across North Carolina: Moving Forward

The table on the following pages lists the 54 strategies recommended in this plan, together with:

- Timetable for implementation
- Estimated annual investment required for implementation
- Agencies or institutions responsible for implementation
- Measures of success for evaluating each strategy.

It should be emphasized that investment figures are *preliminary estimates*, based on data available at the time of this writing. As planning for activities goes forward and strategies are refined, estimates will be revised. In some cases, the levels of investment remain to be determined (TBD) until the strategies are more clearly defined.

In all cases, the investments listed represent *new* dollars, over and above current funding levels of designated institutions or agencies.

The assignment of investment amounts to specific fiscal years implies a schedule for each activity, with most beginning in the first year of this plan. In several cases, investment levels assume a scaling up or down of the level of activity over time. In many cases these implementation schedules will need to be adjusted when plans are more concrete.

New Jobs Across North Carolina: Moving Forward

#	Strategy	Timetable	Required Investment
		(Preliminary estimates)	
Generate New Ideas: Recommended Strategies			
	Attract and retain research talent.		
1	Re-commit to funding the existing endowed chairs for faculty and establish a general fund for faculty start-up packages.	FY2005 FY2006 FY2007 FY2008 FY2009	\$10,000,000 \$10,000,000 \$10,000,000 \$10,000,000 \$10,000,000
2	Recruit targeted faculty through the Biotechnology Center's Faculty Recruitment Grant Program.	FY2005 FY2006 FY2007 FY2008 FY2009	\$2,000,000 \$2,500,000 \$3,000,000 \$3,000,000 \$3,000,000
3	Recruit top graduate students.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
	Build statewide biotechnology research infrastructure.		
4	Renew and expand state funding for equipment and instrumentation through Biotechnology Center programs.	FY2005 FY2006 FY2007 FY2008 FY2009	\$2,000,000 \$2,500,000 \$3,000,000 \$3,500,000 \$4,000,000
5	Develop a statewide network of research centers focused on key regional resources.	FY2005 FY2006 FY2007 FY2008 FY2009	\$200,000 \$5,200,000 \$7,200,000 \$9,200,000 \$11,200,000
6	Seek federal funds to create a powerful statewide information technology infrastructure.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
	Support innovative research.		
7	Support early-stage applied research through Biotechnology Center Academic Research Initiation Grants.	FY2005 FY2006 FY2007 FY2008 FY2009	\$1,000,000 \$2,000,000 \$2,000,000 \$3,500,000 \$3,500,000

#	Parties Responsible	Success Measures
<i>Generate New Ideas: Recommended Strategies</i>		
<i>Attract and retain research talent.</i>		
1	UNC System	Track results obtained by endowed faculty, including: <ul style="list-style-type: none"> • Amount of federal funding received • Number of invention disclosures • Number of patents • Number of licenses • Number of companies established • Number of publications
2	Biotechnology Center	Track results obtained by recruited faculty, including: <ul style="list-style-type: none"> • Amount of federal funding received • Number of invention disclosures • Number of patents • Number of licenses • Number of companies established • Number of publications
3	UNC System	<ul style="list-style-type: none"> • Number of graduate students in biotechnology-related areas • Number of these students who remain in North Carolina after completing their studies
<i>Build statewide biotechnology research infrastructure.</i>		
4	Biotechnology Center	<ul style="list-style-type: none"> • Number of awards made
5	Biotechnology Center	Amount of regional center funding versus: <ul style="list-style-type: none"> • Number of faculty recruited to regional centers • Amount of federal funding obtained by regional centers • Level of technology transfer activities at regional centers
6	North Carolina Genomics and Bioinformatics Consortium	<ul style="list-style-type: none"> • Funds received from the federal government
<i>Support innovative research.</i>		
7	Biotechnology Center	Track results obtained by faculty, including: <ul style="list-style-type: none"> • Amount of federal funding received • Number of invention disclosures • Number of patents • Number of licenses • Number of companies established • Number of publications

New Jobs Across North Carolina: Moving Forward

#	Strategy	Timetable	Required Investment
		(Preliminary estimates)	
Move Ideas to Market: Recommended Strategies			
	Transform new ideas into commercial opportunity.		
8	Provide universities with the resources and flexibility to structure technology transfer offices that meet their unique needs.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
	Make the university-industry connection.		
9	Utilize existing and new research parks to facilitate regional biotechnology development.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
10	Establish university leadership/economic development networks.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- -0- -0- -0- -0-
11	Strengthen ties between universities and industry.	FY2005 FY2006 FY2007 FY2008 FY2009	\$250,000 \$250,000 \$250,000 \$250,000 \$250,000
	Support the scientist-entrepreneur.		
12	Define the economic development missions of the universities.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- -0- -0- -0- -0-
13	Incorporate an evaluation of "total impact" into faculty promotion and tenure decisions.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- -0- -0- -0- -0-
14	Provide support to faculty for pursuing entrepreneurial endeavors and entrepreneurial sabbaticals.	FY2005 FY2006 FY2007 FY2008 FY2009	\$500,000-\$1,000,000 \$500,000-\$1,000,000 \$500,000-\$1,000,000 \$500,000-\$1,000,000 \$500,000-\$1,000,000

#	Parties Responsible	Success Measures
Move Ideas to Market: Recommended Strategies		
Transform new ideas into commercial opportunity.		
8	UNC System	<ul style="list-style-type: none"> • Number of patents • Number of inventions disclosures • Number of licensing deals • Number of company start-ups
Make the university-industry connection.		
9	UNC System	<ul style="list-style-type: none"> • Number of Millenium-type campuses established • Number and identity of tenants on those campuses • Level of sponsored research from park tenants • Number of students employed by park tenants
10	Biotechnology Center in partnership with the UNC System, the Department of Commerce, and the Small Business and Technology Development Center	<ul style="list-style-type: none"> • Number of business recruitments • Number of business retentions
11	UNC System	<ul style="list-style-type: none"> • Establishment of offices of industrial relations • Dollar amounts of university/industry partnerships and collaborations statewide • Number of graduates trained in North Carolina who are hired by North Carolina companies
Support the scientist-entrepreneur.		
12	UNC System Board of Governors	<ul style="list-style-type: none"> • Final approval of new strategic directions by the UNC System Board of Governors
13	UNC System	<p>In addition to teaching and the preparation of graduate students, faculty should be evaluated on:</p> <ul style="list-style-type: none"> • Number of patents • Number of inventions disclosures • Number of licensing deals • Number of company start-ups • Amount of federal funding received
14	Biotechnology Center	<p>Track results obtained by faculty, including:</p> <ul style="list-style-type: none"> • Number of awards made • Amount of federal funding gained • Number of patents • Number of inventions disclosures • Number of licensing deals • Number of company start-ups • Progress of company start-ups

New Jobs Across North Carolina: Moving Forward

#	Strategy	Timetable	Required Investment
		(Preliminary estimates)	
15	Establish an entrepreneurs-in-residence program.	FY2005 FY2006 FY2007 FY2008 FY2009	\$200,000 per entrepreneur \$200,000 per entrepreneur \$200,000 per entrepreneur \$200,000 per entrepreneur \$200,000 per entrepreneur
Start and Grow New Companies: Recommended Strategies			
Increase sources of early stage investment capital.			
16	Replenish the Biotechnology Center's Economic Development Investment Fund.	FY2005 FY2006 FY2007 FY2008 FY2009	\$2,000,000 \$3,000,000 \$4,000,000 \$5,000,000 \$5,000,000
17	Allocate a small percentage of existing state funds, such as escheat or pension, for investment in biotechnology start-up companies located in North Carolina.	FY2005 FY2006 FY2007 FY2008 FY2009	\$25-50M (invested funds) \$25-50M (invested funds) \$25-50M (invested funds) \$25-50M (invested funds) \$25-50M (invested funds)
18	Modify and create a permanent Qualified Business Ventures (QBV) tax credit.	FY2005 FY2006 FY2007 FY2008 FY2009	\$6,000,000 \$6,000,000 \$6,000,000 \$6,000,000 \$6,000,000
19	Market North Carolina to national and international venture capitalists.	FY2005 FY2006 FY2007 FY2008 FY2009	\$250,000 \$250,000 \$250,000 \$250,000 \$250,000
20	Help companies understand and access federal resources.	FY2005 FY2006 FY2007 FY2008 FY2009	\$100,000 \$100,000 \$100,000 \$100,000 \$100,000
Provide targeted tax relief.			
21	Identify and implement tax policies that support biotechnology company creation and growth.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
Develop successful entrepreneurs.			
22	Create a Biotech Leadership Circle to mentor entrepreneurs.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- -0- -0- -0- -0-

#	Parties Responsible	Success Measures
15	UNC System	<ul style="list-style-type: none"> Number of entrepreneurs-in-residence hired Success of companies that entrepreneurs-in-residence support
Start and Grow New Companies: Recommended Strategies		
Increase sources of early stage investment capital.		
16	Biotechnology Center	<ul style="list-style-type: none"> Number of companies funded Amount of additional public or private investment in funded companies Number of job years created
17	State Treasurer, Biotechnology Center	<ul style="list-style-type: none"> Return on investment Number of companies funded Amount of additional public and private investment in funded companies Number of job years created
18	Department of Revenue	<ul style="list-style-type: none"> Total annual investment in qualified R&D companies Number of individual investors Qualified investments per year that exceed the QBV cap
19	Department of Commerce, Biotechnology Center	<ul style="list-style-type: none"> Number of venture capital funds investing in North Carolina companies for the first time Number of investments by these funds Number of repeat venture capital investments by these funds Total annual investments by these funds
20	Small Business and Technology Development Center, Council for Entrepreneurial Development, North Carolina Biosciences Organization, Biotechnology Center	<ul style="list-style-type: none"> Number of companies that apply for federal grants Number of companies that receive federal grants Federal funding received by companies Number of federal collaborations established
Provide targeted tax relief.		
21	General Assembly, North Carolina Biosciences Organization, Department of Revenue	TBD
Develop successful entrepreneurs.		
22	Council for Entrepreneurial Development, Biotechnology Center, North Carolina Biosciences Organization, Small Business and Technology Development Center	<ul style="list-style-type: none"> Number of entrepreneurs participating as mentors Number of entrepreneurs mentored Informal feedback

New Jobs Across North Carolina: Moving Forward

#	Strategy	Timetable	Required Investment
		(Preliminary estimates)	
23	Provide leadership training for early stage managers and founders.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- -0- -0- -0- -0-
Attract and Grow Companies: Recommended Strategies			
Empower the Department of Commerce.			
24	Provide adequate staff to the North Carolina Department of Commerce to enable it to pursue aggressive recruitment activities.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
25	Evaluate opportunities to forge international partnerships strategically valuable to North Carolina's recruitment efforts and the state's biotechnology community.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
26	Establish a Hot Opportunities Team to coordinate the state's recruitment of "hot" company prospects and retention of companies at risk of leaving North Carolina.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- -0- -0- -0- -0-
Market North Carolina.			
27	Provide adequate funding to the Commerce Department to support the creation and execution of targeted marketing strategies that effectively sell North Carolina's life sciences assets.	FY2005 FY2006 FY2007 FY2008 FY2009	\$5,000,000 \$5,000,000 \$5,000,000 \$5,000,000 \$5,000,000
Close the deal: create competitive financial incentives.			
28	Create a special incentive fund for major life sciences company recruitments.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
29	Fully fund the One North Carolina Fund.	FY2005 FY2006 FY2007 FY2008 FY2009	\$15,000,000 \$15,000,000 \$15,000,000 \$15,000,000 \$15,000,000
30	Lift restrictions (or provide exceptions to limits) on North Carolina's Job Development Investment Grants.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD

#	Parties Responsible	Success Measures
23	Council for Entrepreneurial Development, North Carolina Biosciences Organization, Biotechnology Center, university business schools	<ul style="list-style-type: none"> Number of participants Number of courses offered
Attract and Grow Companies: Recommended Strategies		
Empower the Department of Commerce.		
24	Department of Commerce	<ul style="list-style-type: none"> Number of qualified prospects Number of successful recruitments Number of jobs/job-years created
25	Department of Commerce, Biotechnology Center	<ul style="list-style-type: none"> Measures would be collaboration-specific
26	Department of Commerce, Biotechnology Center	<ul style="list-style-type: none"> Informal feedback
Market North Carolina.		
27	Department of Commerce	<ul style="list-style-type: none"> Number of qualified prospects Number of successful recruitments Number of jobs/job-years created
Close the deal: create competitive financial incentives.		
28	Department of Commerce	<ul style="list-style-type: none"> Number of successful recruitments using these funds Level of investment per company recruited Number of jobs created
29	Department of Commerce	<ul style="list-style-type: none"> Number of companies receiving investment Level of investment per company Number of jobs retained or created
30	Department of Commerce	<ul style="list-style-type: none"> Number of jobs retained or created

New Jobs Across North Carolina: Moving Forward

#	Strategy	Timetable	Required Investment
		(Preliminary estimates)	
31	Support financing for companies building biomanufacturing plants in North Carolina through credit-enhancing vehicles.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
Address the needs of bioscience businesses already in North Carolina.			
32	Survey the status and needs of biotechnology, biomanufacturing and other life sciences companies located throughout the state.	FY2005 FY2006 FY2007 FY2008 FY2009	\$500,000 - \$1,000,000 \$500,000 - \$1,000,000 \$500,000 - \$1,000,000 \$500,000 - \$1,000,000 \$500,000 - \$1,000,000
Train the Workforce: Recommended Strategies			
33	Fund continuing education programs at the community colleges at the same level as curriculum programs.	FY2005 FY2006 FY2007 FY2008 FY2009	\$3,000,000 \$3,000,000 \$3,000,000 \$3,000,000 \$3,000,000
34	Provide an Innovation Fund for the Community College System to support biotechnology initiatives.	FY2005 FY2006 FY2007 FY2008 FY2009	\$2,000,000 \$2,000,000 \$2,000,000 \$2,000,000 \$2,000,000
35	Upgrade community college science and engineering technology laboratories.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- \$5,000,000 \$5,000,000 \$5,000,000 \$5,000,000
36	Provide continuation funding for the Biomanufacturing and Pharmaceutical Training Consortium.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- \$6,000,000 \$12,000,000 \$12,000,000 \$12,000,000
37	Provide professional development opportunities for faculty.	FY2005 FY2006 FY2007 FY2008 FY2009	\$100,000 \$100,000 \$150,000 \$200,000 \$200,000
38	Develop and implement industry-approved certifications.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- \$150,000 \$200,000 \$200,000 \$50,000
39	Provide support for innovative program development.	FY2005 FY2006 FY2007 FY2008 FY2009	\$150,000 \$150,000 \$150,000 \$150,000 \$150,000

#	Parties Responsible	Success Measures
31	General Assembly	<ul style="list-style-type: none"> Number of biomanufacturing facilities financed Amount of additional public or private investment in companies financed Number of jobs created
Address the needs of bioscience businesses already in North Carolina.		
32	Department of Commerce, Local economic developers	<ul style="list-style-type: none"> A yearly report of common needs or problems for North Carolina biotech companies Number of companies at risk of leaving North Carolina Number of at-risk companies choosing to remain in North Carolina
Train the Workforce: Recommended Strategies		
33	Community College System	<ul style="list-style-type: none"> Implementation of continuing education courses relevant to biotechnology industry sector Instructor and employer satisfaction with teaching facilities and support Industry satisfaction with courses and graduates
34	Community College System	<ul style="list-style-type: none"> Sustained enrollment to meet Industry needs Industry satisfaction with graduates and relevance of curricula
35	Community College System	<ul style="list-style-type: none"> Improved student performance in higher-level courses Implementation of biotechnology-related material and more hands-on experimentation in curricula statewide Enhanced recruitment and retention of students in science programs
36	Biomanufacturing and Pharmaceutical Training Consortium	<ul style="list-style-type: none"> Employment of graduates in North Carolina companies Enrollment Satisfaction of incumbent employees with programs Level of continuing industry support to the Consortium
37	Biotechnology Center	<ul style="list-style-type: none"> Faculty/staff enrollment in programs Implementation of industrially-relevant material in courses and curricula
38	Biotechnology Center and professional organizations	<ul style="list-style-type: none"> Industry participation in developing certifications Company recognition of certificates in hiring and promoting employees Stimulation of targeted curriculum development in colleges Recognition of North Carolina's leadership in workforce development
39	Biotechnology Center	<ul style="list-style-type: none"> Level of access by students statewide to up-to-date equipment and the newest technologies Effectiveness with which colleges implement new curricula that meet Industry needs

New Jobs Across North Carolina: Moving Forward

#	Strategy	Timetable	Required Investment
		(Preliminary estimates)	
40	Expedite the implementation of articulation agreements between community colleges and universities.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- -0- -0- -0- -0-
41	Provide basic curriculum resources about the industry.	FY2005 FY2006 FY2007 FY2008 FY2009	\$100,000 \$300,000 \$300,000 \$300,000 \$75,000
42	Establish a Biotechnology Workforce Advisory Council.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- -0- TBD TBD TBD
Strengthen K-12 Math and Science: Recommended Strategies			
43	Support and expand the North Carolina Infrastructure for Science Education.	FY2005 FY2006 FY2007 FY2008 FY2009	\$100,000 \$200,000 \$350,000 \$350,000 \$350,000
44	Capitalize on the grant to North Carolina from the Gates Foundation to create innovative schools for biotechnology.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
45	Require proficiency in inquiry-based science teaching methods for teacher accreditation.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
46	Enhance professional development experiences for teachers.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- \$100,000 \$200,000 \$200,000 \$300,000
47	Strengthen Career and Technical Education curricula in biotechnology.	FY2005 FY2006 FY2007 FY2008 FY2009	\$180,000 \$100,000 \$100,000 \$100,000 \$100,000
48	Support curriculum development and provide resources for teaching biotechnology-related science.	FY2005 FY2006 FY2007 FY2008 FY2009	\$60,000 \$60,000 \$180,000 \$180,000 \$160,000

#	Parties Responsible	Success Measures
40	Community College System and UNC System	<ul style="list-style-type: none"> Extent to which appropriate Associate of Science degree courses are accepted by all UNC System institutions Extent to which Associate of Applied Science programs are articulated with minimal loss of credit to baccalaureate science/technology programs
41	Biotechnology Center	<ul style="list-style-type: none"> Effectiveness of counseling of K-12 and college students about biotechnology careers Implementation of curriculum materials covering pharmaceutical and biotechnology Industry operations and Good Manufacturing Practices
42	Biotechnology Center	<ul style="list-style-type: none"> K-12 schools, community colleges, and universities statewide have consistent, coordinated leadership from industry to inform and shape education and training programs
Strengthen K-12 Math and Science: Recommended Strategies		
43	North Carolina Infrastructure for Science Education	<ul style="list-style-type: none"> Higher student scores on math and science tests, as well as in reading and writing Expression of continued student interest in science as students move into higher grades
44	Gates Foundation Grant administrators; participating school districts	<ul style="list-style-type: none"> Number of innovative schools with a biotechnology focus that are established Graduation rate increases Number of graduates pursuing industrial careers paths
45	State Board of Education and Department of Public Instruction	<ul style="list-style-type: none"> Number of teachers using effective science teaching methods Higher student scores in science and more students taking advanced science courses
46	Biotechnology Center	<ul style="list-style-type: none"> Implementation of biotechnology-related material in basic as well as advanced middle school and high school biology and chemistry courses statewide
47	Department of Public Instruction and Biotechnology Center	<ul style="list-style-type: none"> Number of middle school students learning about careers in biotechnology Number of high school students entering community college programs leading to industrial careers in biomanufacturing or other relevant career paths
48	Biotechnology Center and Science, Math, and Technology Education Center	<ul style="list-style-type: none"> Implementation of biotechnology-related material in basic as well as advanced middle school and high school biology and chemistry courses statewide

New Jobs Across North Carolina: Moving Forward

#	Strategy	Timetable	Required Investment
		(Preliminary estimates)	
Strengthen Biotechnology Statewide: Recommended Strategies			
49	Assist communities statewide, particularly rural ones, to identify niche opportunities and target resources for building biotechnology-related activities.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
50	Provide funding for the Biotechnology Center to establish and maintain permanent satellite offices statewide.	FY2005 FY2006 FY2007 FY2008 FY2009	\$1,000,000 \$1,500,000 \$1,500,000 \$2,000,000 \$2,000,000
51	Charge the Biotechnology Center with leadership for North Carolina’s biotechnology policies and strategies, including implementation of the Strategic Plan.	FY2005 FY2006 FY2007 FY2008 FY2009	TBD TBD TBD TBD TBD
52	Inform and engage the Governor, Lt. Governor, General Assembly, and Council of State in issues critical to biotechnology development.	FY2005 FY2006 FY2007 FY2008 FY2009	-0- -0- -0- -0- -0-
53	Establish a forum at the Institute for Emerging Issues for the timely and responsible discussion of ethical, cultural, societal and policy issues of biotechnology.	FY2005 FY2006 FY2007 FY2008 FY2009	\$250,000 \$250,000 \$250,000 \$250,000 \$250,000
54	Increase funding for the Board of Science and Technology.	FY2005 FY2006 FY2007 FY2008 FY2009	\$1,000,000 \$1,000,000 \$1,500,000 \$1,500,000 \$1,500,000

#	Parties Responsible	Success Measures
Strengthen Biotechnology Statewide: Recommended Strategies		
49	Biotechnology Center with educational, governmental, economic development, and private parties statewide	<ul style="list-style-type: none"> • Specific measures TBD • Broad outcomes: increases in regional biotechnology companies, workers, educational programs, investments, and related applications
50	Biotechnology Center with regional partners	<ul style="list-style-type: none"> • Four staffed satellite offices established by end of calendar year 2004 • Specific measures TBD by each region • Broad outcomes: increases in regional biotechnology companies, workers, educational programs, investments, and related applications
51	Biotechnology Center with participants in biotechnology development statewide	<ul style="list-style-type: none"> • Reports on status, development, and changes in North Carolina's biotechnology plan and implementation of required strategies • Verifiable information, reports, and briefings statewide on suggested new strategies, modifications, or opportunities for biotechnology development
52	Biotechnology Center with participants in biotechnology development statewide	<ul style="list-style-type: none"> • Reports on the status, development, and opportunities for biotechnology development statewide
53	Institute for Emerging Issues with university and institutional partners	<ul style="list-style-type: none"> • Annual meetings, reports, and analyses to inform public and governmental understanding and when possible practical policy
54	Board of Science and Technology, Department of Commerce, Office of the Governor	<ul style="list-style-type: none"> • Identification of key new sectors or developments by commissioned analyses and reports • Annual funding of 4-8 Opportunity Grants for initial exploration of those sectors

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